THE UNIVERSITY OF ALBERTA

A RECLASSIFICATION OF BOMBARDIER BEETLES AND A TAXONOMIC REVISION OF THE NORTH AND MIDDLE AMERICAN SPECIES (CARABIDAE: BRACHINIDA)

BY

© TERRY LEE ERWIN

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AUTOBIOGRAPHY

I was born in Saint Helena, California, December 1, 1940. My childhood days were spent in Vallejo, California. My formal schooling, grades 1-14, were spent in the Vallejo School System. I graduated from Vallejo Junior College with an Associate of Arts degree in 1961, and entered San Jose State College as a Junior. My interest in entomology, and subsequently carabid beetles, began in General Entomology 51 (now 101) at San Jose in 1962. I switched my major to Entomology and subsequently received my Bachelor of Arts degree in that subject in 1964, whereupon I began work on a Master of Arts in the same Department under the direction of Dr. J. Gordon Edwards. At his suggestion, I began the study of bombardier beetle taxonomy and life history. During two summers, while working on my Masters degree, I supported my wife and myself working at the Santa Clara County Health Department (Vector Control) on Blow Fly and Midge Problems. I shared a grant with R. D. Spadoni during the summer of 1965 working on Blow Fly problems in residential garbage cans. Also during these two years, I published my Revision of California Brachinus and three notes concerning Buprestidae, Helodidae, and Brachinus life history. In 1966, I received my Masters of Arts in Biological Science and was accepted as a Ph. D. student at the University of Alberta under the direction of Dr. G. E. Ball. In 1967, I was awarded a National Research Council Scholarship to continue my studies at the University of Alberta. I also published my paper on the life history of Brachinus pallidus Erwin in California. My Scholarship was renewed for 1968. Upon the completion of this thesis and its defense, I will become a Research Fellow at the MCZ.

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled A Reclassification of Bombardier Beetles and A Taxonomic Revision of the North and Middle American species (Carabidae: Brachinida) submitted by Terry Lee Erwin in partial fulfilment of the requirements for the degree of Doctor of Philosophy

ABSTRACT

A taxonomic revision of the species of the North and Middle American Brachinus Weber is presented. Sixty-two species are recognized as valid. Neobrachinus new subgenus, is erected to contain the New World species formerly included in Brachinus (sensu stricto). The following 20 taxa are described as new: Brachinus alexiguus, B. microamericanus, B. capnicus, B. chalchihuitlicue, B. chirriador, B. adustipennis, B. cibolensis, B. kavanaughi, B. javalinopsis, B. imporcitis, B. oaxacensis, B. galactoderus, B. cyanochroaticus, B. ichabodopsis, B. fulminatus, B. vulcanoides, B. mobilis, B. explosus, B. aabaaba, B. sonorous. Twenty-five names are reduced to synonymy for the first time.

A key to the species is given. Each species and species group is described and synonymies are listed. The distribution of each species is presented by locality records and distribution maps. Structures used in identification are illustrated. Two species of Pheropsophidius Hubenthal occur in Middle America and are included in the key to bombardier beetles of North and Middle America; one of these species is described. Structures of both species are illustrated.

A reclassification of the genera of the world bombardier beetles is presented. Seventeen genera are recognized as valid. These include 13 valid subgenera, one of which is new. Five subtribes, two of which are new, three of which have new status, include the seventeen genera. Two tribes are included in the Division Brachinida. Three generic names are reduced to

Continued. . . .

Abstract (Con't)

synonymy for the first time. All taxa are described and keys for their identification are presented.

A discussion of the general morphology of members of the genera is presented. Structures discussed are illustrated.

A hypothetical phylogeny is presented for all genera of the Division Brachinida and all species of *Neobrachinus* new subgenus. The geographical distribution of these taxa is also discussed. Figures and tables accompany the discussions.

ACKNOWLEDGEMENTS

Special thanks are due the following people who have contributed their time to the completion of this manuscript.

Dr. G. E. Ball has displayed continued interest, encouragement, aid, and guidance throughout this entire study. Free access to his library has been most helpful. He also spent several days comparing Dejean and Chaudoir types of Brachinus in Paris for me, and I thank him for reading and editing this manuscript.

Dr. W. G. Evans, Dr. J. S. Nelson, and Dr. J. G. Packer, members of my committee, read and criticized the manuscript and offered many helpful suggestions. I thank these gentlemen. I also thank Dr. R. T. Bell for reading and criticizing the manuscript, and Dr. J. G. Edwards for reading and criticizing great portions of the manuscript.

My wife, La Verne J. Erwin, has been more than helpful with her time and patience. She typed the manuscript, read it, and criticized it, and I am especially grateful for her continued assistance in field work and curation of specimens.

I owe much gratitude to the numerous people listed in Section 2.1 for the loan of the specimens which were the foundation for this study. I want to thank also Dr. R. B. Madge (British Museum of Natural History, London) and Mr. E. Taylor (Hope Museum, Oxford) for examining type material for me.

Dr. P. J. Darlington, Jr., and Dr. J. N. L. Stibeck showed my wife and me many courtesies when I examined type specimens in their charge and I thank them heartily.

ACKNOWLEDGEMENTS (Con't.)

Thanks are also due to Mr. D. R. Whitehead for criticizing the key to Neobrachinus, suggestions he made on the illustrations, and for many discussions we have had on ground beetles in general. I thank Dr. C. H. Lindroth for continued encouragement and aid. I also wish to thank Miss Joan Shore, Administrative Assistant, for many courtesies she has extended to me throughout the course of this study. I thank Dr. E. C . May, Department of Classics, for his comments on my new trivial names. I am indebted to Dr. B. S. Heming and Mr. A. P. Nimmo for the aid given me in regard to illustrations, and also to Dr. D. A. Craig for discussions we had on external morphology.

Many thanks are due also to my good friends, Dick and Alice Daly, for helping in the great task of hand collating the thesis and for many "little things" that are important when one undertakes a task of this sort.

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1.0 INTRODUCTION

The bombardier beetles are a complex and taxonomically difficult group belonging to the Family Carabidae. In 1862, LeConte stated: "I must also add that I consider the species of this genus very decidedly opinionative, and that I am only impelled to the publication of this note by the necessity of giving names to a certain number of recognized forms, and of placing as synonyms some which I formerly considered as distinct, but which increased collections have since shewn to be varieties."

Some 98 years later, the situation had hardly changed, and Ball (1960:164) wrote: "The taxonomy of the North American species of this group is very poorly understood and it is almost a waste of time at present to attempt to determine individuals to species."

Until now, a taxonomic revision of all North and Middle American species of Brachinus has not been undertaken, probably because of the great morphological similarity among the species, a lack of traditional characteristics for separating the species, and the unavailability of much of the "type" material. The first of these obstacles was surmounted after the discovery of external characteristics not used previously. The last problem was resolved with the help of G. E. Ball who compared my specimens with the type material of Dejean and Chaudoir in Paris. I was able to compare the LeConte and Blatchley types myself at the Museum of Comparative Zoology and Purdue University, respectively.

The present paper is an extension of my 1965 publication and deals with the taxonomy and distribution of Brachinus and Pheropsophidius in North and Middle America. I also propose here

a reclassification of bombardier beetles of the world, including subgeneric components; discuss phylogenetic and zoogeographic hypotheses; and present a preliminary study of the comparative morphology of bombardier beetles.

Bombardier beetles were first recognized formally when Linné described the species Carabus crepitans in 1758. Since that time, more than 600 trivial names have been proposed for members of the Brachinida.

Dejean (1825, 1831), LeConte (1844, 1848, 1858, 1862), and Chaudoir (1868, 1876) have described most of the species in North and Middle America. Chaudoir's paper (1876) has been the only monographic treatment of the Brachinida as a whole. Basilewsky's 1959 revision of the Crepidogastrini must be considered monographic of that tribe. LeConte's 1862 paper and my revision of the California species (1965) contain the only new keys to North American species. (Blatchley's 1910 monumental "Coleoptera of Indiana" contains a key to the Brachinus species of Indiana, but it was based on LeConte's key.)

Many faunal studies have included partial taxonomic treatment of some of the taxa of the Brachinida. Notable are publications by Antoine (1962), Basilewsky (1962), Darlington (1968), Habu (1967), Jeannel (1942, 1949), Liebke (1934), Peringuey (1885, 1888, 1896, 1898), and Reitter (1919).

No complete taxonomic classification has been proposed for the group as a whole. Most workers still seem to rely more heavily on the catalogue classification established by Csiki (1933) than on any other reference source.

2.0 MATERIALS AND METHODS

2.1 Materials

This study is the result of the examination of 28,633 specimens of North and Middle American *Brachinus*, and 2,172 specimens of other bombardier beetles. Most of these specimens have been loaned to me by various museums and private collectors in Canada, Europe, Mexico, and the United States. The others were collected by my wife and me in the United States. Were it not for the intensive collecting of carabids in Mexico by G. E. Ball and D. R. Whitehead, this area would have been omitted from this study due to insufficient material. Larval material was especially difficult to obtain. In addition to material from California (Erwin, 1967), I have seen one first instar larva of *Brachinus mexicanus* Dejean, and one unidentified last instar larva. This is still all that is known in North America, besides that which H. F. Wickham collected in the 1890's.

The following abbreviations indicate the various museums and private collections from which specimens were borrowed:

AMNH American Museum of Natural History, New York, New York 10024, P. Vaurie

ANSP Academy of Natural Sciences, Philadelphia, Pennsylvania 19103, H. R. Roberts

AUAA Auburn University, Auburn, Alabama 36830, K. L. Hays

BMNH British Museum (Natural History), London, England, R. D. Pope

CArm C. Armin, 191 West Palm Avenue, Reedley, California 93654

CAS California Academy of Sciences, San Francisco, California 94118, H. B. Leech

CBak	C. Baker, California State Polytechnic College, San Luis Obispo, California 93401
CCha	C. Chantel, 425 Saint Olivier, Quebec 4, Quebec
CEWh	C. E. White, 2441 East Northview Avenue, Indianapolis, Indiana 46220
CMPP	Carnegie Museum, Pittsburgh, Pennsylvania 15213, G. E. Wallace
CNC	Canadian National Collection of Insects, Entomology Research Institute, Ottawa, Ontario, E. C. Becker, W. J. Brown
CNHM	Chicago Natural History Museum, Chicago, Illinois 60605, H. Dybas
CPBo	C. Pieltain y Bolivar, Instituto Politecnico Nacional, Mexico D. F.
CUNY	Cornell University, Ithaca, New York, 14850, L. L. Pechuman
CVMA	Coachella Valley Mosquito Abatement District Collection, Thermal, California 92274
DDLa	D. J. Larson, University of Calgary, Calgary, Alberta
DHKa	D. H. Kavanaugh, 960 Clay Way, Denver, Colorado 80204
DRWh	D. R. Whitehead, University of Alberta, Edmonton 7, Alberta
DTRT	Division of Tropical Research, Tela Railroad Company, La Lima, Honduras, Central America, W. G. C. Forsyth
FDAG	Florida Department of Agriculture, Gainesville, Florida 32601, R. E. Woodruff
GRNo	G. R. Noonan, University of California, Riverside, California 92502 (including collection of F. Andrews)
HGou	H. Goulet, University of Alberta, Edmonton 7, Alberta
HMO	Hope Museum, Oxford, England, E. Taylor
ISNH	Illinois State Natural History Survey, Urbana, Illinois

61803, L. K. Gloyd

ISUA Iowa State University, Ames, Iowa 50010, J. Laffoon

JHen J. Hendrichs, Mixcoac, Mexico 19, D. F.

JSch J. Schuh, 4039 Shasta Way, Klamath Falls, Oregon 97601

KMTB Koninklijk Museum Voor Midden-Afrika-Musée Royal del' Afrique Centrale, Tervuren, Belgium, P. Basilewsky

KSU Kansas State University, Manhattan, Kansas 66502, H. D. Blocker

LACM Los Angeles County Museum, Exposition Park, Los Angeles California 90007, C. L. Hogue

LBSC Long Beach State College, Long Beach, California 90804, E. L. Sleeper

LRus L. Russell, University of Washington, Seattle, Washington 98105

LSUB Louisiana State University, Baton Rouge, Louisiana 70803, J. B. Chapin

MSUM Montana State University, Missoula, Montana, 59801, N. Anderson

MCZ Museum of Comparative Zoology, Cambridge, Massachusetts 02138, P. J. Darlington, Jr.

MHNP Museum National d' Histoire Naturelle, Paris, A. Bons

MMM Moscow Museum, Moscow, U.S.S.R.

NSDA Nevada State Department of Agriculture, Reno, Nevada, 89504, R. C. Bechtel

OSUC Oregon State University, Corvalis, Oregon 97331, P. O. Ritcher

OSUS Oklahoma State University, Stillwater, Oklahoma 74075, W. A. Drew

OUCO Ohio State University, Columbus, Ohio 43210, C. A. Triplehorn

PSUU Pennsylvania State University, University Park, Pennsylvania 16802, W. W. Boyle, S. W. Frost

PUM Purdue University, Lafayette, Indiana 47907, R. H. Arnett

RCGr R. C. Graves, Bowling Green State University, Bowling Green, Ohio 43402 (including collection of W. Suter)

RESt R. E. Stecker, San Jose State College, San Jose, California 95114

RFre R. Freitag, Lakehead University, Lakehead, Ontario

ROM The Royal Ontario Museum, University of Toronto, Toronto 5, Ontario, G. B. Wiggins

RTBe R. T. Bell, University of Vermont, Burlington, Vermont 05401

SDSNH San Diego Society of Natural History, San Diego, California 92112, C. F. Harbison

SDSU South Dakota State University, Brookings, South Dakota 57006, E. U. Balsbaugh, Jr.

SJSC San Jose State College, San Jose, California 95114, J. G. Edwards

TAMU Texas A & M University, College Station, Texas 77840, H. R. Burke

TCBa T. C. Barr, Jr., University of Kentucky, Lexington, Kentucky 40506

TFHl T. F. Hlavac, Purdue University, Lafayette, Indiana 47907

TLEr T. L. Erwin, University of Alberta, Edmonton 7, Alberta

TMBH Termeszettudomanyi Múzeum, Musée Hongrois d'Histoire Naturelle, Budapest, VIII., Baross-u. 13. (Hongrie), Z. Kaszab

UAFA University of Arkansas, Fayetteville, Arkansas 72701, R. T. Allen, E. P. Rouse

UASM University of Alberta, Strickland Museum, Edmonton 7, Alberta, G. E. Ball

UATA University of Arizona, Tucson, Arizona 85721, F. G. Werner

UBC University of British Columbia, Vancouver, British Columbia

UCD University of California, Davis, California 95616, R. O. Schuster

UCR University of California, Riverside, California 92502, S. Frommer

UIMI University of Idaho, Moscow, Idaho 83843, W. F. Barr

ULLK University of Louisville, Louisville, Kentucky 40208, C. V. Covell

UMAH University of Michigan, Ann Arbor, Michigan 48104, R. D. Alexander

UMCP University of Maryland, College Park, Maryland 20742, F. E. Wood

UMSP University of Minnesota, Saint Paul, Minnesota 55101, P. Clausen

UNCR University of North Carolina, Raleigh, North Carolina 27607, D. A. Young

UNLN University of Nebraska College of Agriculture, Lincoln, Nebraska 68508, W. T. Atyeo

UNSS University of Saskatchewan, Saskatoon, Saskatchewan, N. Church

UONO University of Oklahoma, Norman, Oklahoma 73069, C. E. Hopla

USNM Smithsonian Institution, Washington, D. C. 20560, O. L. Cartwright

USUL Utah State University, Logan, Utah 84321, W. J. Hanson

UWLW University of Wyoming, Laramie, Wyoming 82070, N. L. Marston

UWMW University of Wisconsin, Madison, Wisconsin 53706, R. D. Shenefelt

UWSW University of Washington, Seattle, Washington 98105, M. H. Hatch

VMKi V. M. Kirk, North Grain Insects Research Laboratories, Brookings, South Dakota 57006

VVBa V. V. Baicher, San Jose State College, San Jose, California 95114

WHTy W. H. Tyson, 823 Cashew Way, Fremont, California 94536

WSUP Washington State University, Pullman, Washington 99163, M. T. James

ZMLS Zoological Institute, University of Lund, Lund, Sweden, C. H. Lindroth

2.2 Methods

2.21 Dissecting techniques

Essentially the same techniques were utilized that have previously been described elsewhere (Erwin, 1965). However, instead of the dissected male genitalia being stored in vials of 70% alcohol they were glued to cards, which were subsequently pinned beneath the specimens.

For storing the female genitalia and various sclerites (described under comparative morphology) the same procedure was followed. The specimens that were completely disarticulated were stored in vials of 70% ethyl alcohol.

2.22 Measurements

Total length measurements were made on representatives of all species. The purpose of this measurement is to give a general

impression of the size range of a species. The great variation in size of adults within any single species of these beetles is due to differences in amount of their larval food (Erwin, 1965). The overall length of adult specimens was obtained in the following manner. From the material at hand, I visually selected both the largest and the smallest specimen, and measured the head from the anterior edge of the labrum to the center of the occipital ridge, the pronotum from the anterior margin to the posterior margin along the center line, and the left elytron from the apex of the scutellum to the elytral apex, along the suture. These three measurements were added together, providing a figure that is not affected by expansion and contraction of the membraneous parts in different killing agents, or by the swelling of the abdomen in gravid females and engorged beetles. A micrometer eyepiece in a Leitz stereoscopic microscope at a magnification of 50 diameters was used for these measurements. The scale interval represented 0.025 mm.

2.23 Illustrations

All drawings were prepared with the aid of a camera lucida on a Wild M5 stereoscopic microscope. After the outline was drawn with the camera lucida, the specimen was examined with the Lietz microscope under higher magnification and finer details and shading were added to the drawings. Accompanying scale lines equal 1.0 mm.

In Section 4, individual distribution maps are given for all species discussed in this paper. In Section 7, I used a modified form of Darlington's (1957) orthographic projection map, because it allows broad patterns to be seen clearly.

2.24 Procedural methods

The 28,633 specimens of North and Middle American bombardier beetles were first categorized according to smaller geographic areas, for example, southern United States, northeastern United States, Mexico, Great Plains, etc. This reduced the amount of material to be concerned with at any one time. The specimens of each geographical area were divided into population samples on the basis of the label data. Each specimen from a given area was compared with every other specimen from that area, and comparable specimens were grouped into "sets." Each set was then intensively studied, and dissections of the male genitalia were made. Those sets with identical genitalia, and at least one concordant external characteristic in common, were grouped together tentatively until all the material from the entire area had been analyzed. Only the male genitalia were arbitrarily weighed, all other characteristics that were studied were considered of equal value. When specimens were judged to be different, on the basis of their genitalia, and at least one external characteristic, an attempt was made to associate females from the same population sample. In no case was any difficulty encountered in determining probable male-female associations.

Further details concerning the relationships between individuals from different species populations are discussed in Section 6 of this paper.

2.25 Criteria for Species, Subspecies, and Supra-specific taxa

A species may be defined as "a naturally occurring population

(or aggregate of populations) that is reproductively isolated and genetically distinctive" (J. Gordon Edwards, per. comm.). When the biology of a natural population is fairly well known and the criteria of this definition have been met, this definition may be applied with reasonable success in the recognition of species. In the present study, only genitalic and external morphology (including pubescence), color, distribution, and some life history data are used, because these are the only things known about most of the populations treated. When only museum specimens are utilized, different criteria are necessary, to supplant those given in the definition above, yet give approximately the same results in recognizing species. As working criteria for these cases, I use the following: A species is represented by "the sum total of the specimens displaying a multidimensional continuum of characteristics, but ultimately delimited from other such species by gross morphological discontinuities." In this case the characteristics are external morphology (including pubescence), genitalic morphology, and color. The determination of the size and nature of the multidimensional discontinuity or "gap" (Mayr, Linsley, and Usinger, 1953) has traditionally been left to competent taxonomists with extensive experience in the group in question. In most cases, these taxonomists have failed to state what their criteria were when recognizing these gaps. My criteria for recognizing this "gap" are the following: two or more similar forms which are naturally sympatric or allopatric are considered separate species, if they differ in genitalic morphology and at least one external characteristic; allopatric forms are considered conspecific if their genitalic morphology is identical and they show intergradation of external

characteristics in geographically proximal areas (or if no external morphological differences are apparent). Parapatric populations or aggregates of populations (that is, populations which meet only in a very restricted area, such as a single valley or single river system) are considered distinct species, if there is no interlacing of characteristics near the zones of contact. If there is interlacing there, the forms are considered either to be conspecific or to be two hybridizing species, depending upon the nature of the interlacement.

Naming of subspecies has been avoided, because I feel that more criteria than morphological characters of museum specimens is necessary for the recognition of limits of taxa below the species level. Subspecies are geographically or temporally delimited populations within a species that differ from other such populations (but which are capable of interbreeding with those other subspecies). Without extensive information on population dynamics, life histories, and genetic capabilities, subspecies would be ill-defined, and ambiguous trivial names might be introduced into the literature if such taxa were included in the present study.

Supra-specific taxa are groups which are established to include all the taxa of the next lowest rank that demonstrate monophyly. Hennig (1966) argues that all such supra-specific taxa which demonstrate sister relationships be given equal absolute rank, but the practicality of this has been questioned (Ball and Erwin, MS). Many supra-specific taxa presently in use are paraphyletic. In this paper I have realigned the taxa of the Brachinida in accord with Hennig's principles, but I have ranked taxa below the generic level

with practicality in mind.

3.0 COMPARATIVE MORPHOLOGY

3.1 Introduction

Upon discovering the asymmetric anterior tarsal pads in male members of Brachinus crepitans (Linné), Antoine (1962) stated "il est incompréhensible qu'on ne l'ail pas encore signalé ...cet interessant caractère sante aux yeux quand on examine les tarses par leur face inférieure." (It is incomprehensible that no one has yet seen this interesting character which jumps to the eyes when one examines the tarsi on their ventral surface.) This may be said for numerous other characteristics of the external morphology. These beetles have been studied by numerous European biologists for 200 years or more; even so the taxonomy of the group (and many other carabid groups) is still in a state of confusion. There can be only one reason. Those workers viewed the beetles from only the dorsal aspect, because their specimens were usually glued to cards in that position. I doubt that many of them ever examined the ventral side of a bombardier beetle. Numerous excellent characteristics have been overlooked by those using this method of mounting carabid beetles. Had Jeannel seen the aberrant characteristics of Mastax members, he surely would have placed this genus in a Family of its own.

In this section I have attempted a beginning of a comprehensive comparative study of bombardier beetle morphology. The material I have seen that represents species of Old World genera is not extensive. I have not seen any members of species comprising three of the

monotypic genera, but I believe that I have seen enough material to reach some valid conclusions. Based on these conclusions, I have proposed certain hypotheses which must be proved or disproved in subsequent studies. Some of these studies I hope to do myself, yet I also hope this presentation will provide a foundation for others who are interested in joining the study of the evolution and biology of bombardier beetles.

By presenting my findings on the comparative morphology of bombardier beetles as Jeannel (1926) did for the Trechinae, I have established a foundation for phylogenetic considerations, using the principles proposed by Hennig (1966). In this section on "comparative morphology," I have tried to integrate the descriptive phase (Section 4) with my interpretations of the character states. In Section 6, I combine the data of Sections 3 and 4 and apply Hennig's principles.

3.2 General characteristics

3.21 Size

The bombardier beetles range in size from the very small members of some _Mastax_ and _Crepidogastrinus_ species, (2.0 and 3.0 mm respectively) to the very large members of some _Aptinomorphus_ species (30.0 mm).

The members of the genus _Mastax_ are all very small, while beetles of the genus _Pheropsophus_ are large to very large. The remaining genera usually have medium-sized members, but some kinds may vary from small to large (sometimes even intraspecifically). The Crepidogastrini range in size from 3.0 to 16.0 mm, according to Basilewsky (1959).

I have seen specimens of Pheropsophina ranging from 10.0 to 30.0 mm; specimens of Brachinina ranging from 3.0 to 18.2 mm; specimens of Aptinina ranging from 4.5 to 15.0 mm; and specimens of Mastacina ranging from 2.0 to 3.5 mm.

There is considerable variation in size among the members of single species, particularly in the genera *Pheropsophus* and *Brachinus*. I believe that variation in size is due to the ectoparasitoid mode of life described for the larvae of these groups (Habu and Sandanaga, 1965; Habu, 1967; Wickham, 1893, 1894; Erwin, 1967). I have shown (Erwin, 1967) that larvae of *Brachinus pallidus* in California are not host specific, but may attack pupae of at least two, and probably three, species of hydrophilid water beetles. Since one host is eaten by one parasitoid larva, the size of the host (larval food available) determines the size of the resultant adult *Brachinus pallidus*. Habu and Sadanaga (1965) and Habu (1967) have shown that the larva of *Pheropsophus jessoensis* Morawitz is an ectoparasitoid on the egg clutches of *Gryllotalpa africana* Palisot de Beauvois (Orthoptera, Gryllotalpidae). Those egg clutches vary in size (number of eggs), and since the larva attacks only one egg clutch the size of the clutch determines the size of the adult beetle. After the larva begins to undergo hypermetamorphosis, it cannot leave the chamber it invaded, because of the decrease in its leg length and the increase in its body size (Erwin, 1967).

It has been repeatedly observed that the proportions of the individual adults remain constant, regardless of their total size.

3.22 General form

The bombardier beetles are a very homogeneous group. The narrow head and prothorax, together with the wide, truncate elytra and apically protruding abdomen, characterize all species of the Brachinida. Jeannel (1926) established names for four general body forms within the tribe Trechini. Three of these types are found in Brachinida, but they are slightly different from the forms described by Jeannel:

1. _Type ailé_ (long-winged type)—pigmented, large eyes, small pronotum, square elytra with prominent humeri, and large metasternum (includes wing dimorphic species);
2. _Type aptère_ (short-winged type)—pigmented, small or large eyes, enlarged pronotum, elytra short with narrow humeri, and short metasternum;
3. _Type anophthalme_ (eyeless type)—depigmented, blind, enlarged pronotum, elytra short with narrow humeri, and short metasternum.

The members of Mastacina fit Jeannel's "Type ailé." In these beetles, the abdomen is not extended as in the crepidogastrines, but they do have the moniliform antennae of that group.

The members of Pherosophina, Aptinina, and Brachinina all have a similar habitus with filiform antennae, but in members of _Pheropsophidus_, _Pheropsophus_, and _Aptinus_, there is a tendency for the abdomen to extend far beyond the apex of the elytra. These subtribes have some members which correspond to Jeannel's "Type ailé" and others that are "Type aptère."

The members of the Crepidogastrini are the most primitive of the Division Brachinida, and are slightly different in habitus from other bombardier beetles. These beetles generally have very short elytra, exposing at least two full abdominal terga, even when the abdomen is not engorged or gravid. Most members belong to Jeannel's "Type aptère," but those of *Tyronia caeca* Basilewsky and *Brachynillus varendorffi* Reitter belong to "Type anophthalme." Also, the antennae of the crepidogastrines are moniliform rather than filiform.

3.23 Microsculpture

In general the microsculpture of bombardier beetles ranges from regularly to irregularly isodiametric. Slight variation occurs from this basic pattern.

Throughout the Brachinina, Mastacina, and Crepidogastrini, the isodiametric meshes may vary into a granulate condition, in which each individual mesh is a convex bump. In members of *Pheropsophus*, the meshes are extremely fine and barely impressed, and there is a tendency for them to be stretched and arranged into transverse rows. In *Aptinus*, the meshes are also barely impressed, but they are larger than in *Pheropsophus* and arranged in transverse rows particularily on the pronotum. *Aptinoderus* members have the meshes of the head almost effaced. Members of *Styphlomerus* have granulate isodiametric meshes arranged on the elytra as in members of *Mastax*, and producing a "satin" appearance.

3.24 Pubescence

All bombardier beetles maintain at least some body pubescence in

addition to the erect "depression setae" borne by the members of most species, on the elytra, and other variously located setae. The members of Crepidogastrini are totally pubescent, while other bombardier beetles may be totally pubescent or have extensive glabrous areas.

The Mastacina members have glabrous elytra, with the pronotum either glabrous or not. The elytra have erect setae in depressions 2, 4, 6, and 8. The epipleura are pubescent. The apical edges of the elytra are devoid of setae.

The members of Pheropsophina have the elytra almost glabrous, but with erect "depression setae" in all depressions, plus scattered pubescence near the scutellum and along depressions 1 and 8. However, the epipleura are glabrous. The apical edge of the elytra ranges from smooth in members of Aptinomorphus to densely pubescent in members of Pheropsophus (sensu stricto). Some members of all the other Pheropsophina subgenera also have this apical fringe.

Among the Aptinina, the members of Aptinus have elytral pubescence arranged much like that of members of Pheropsophus, but it is usually more dense. Members of Aptinus also have the epipleura pubescent. In Styphlomerus and its allies, the elytra and epipleura are totally pubescent, with an additional apical fringe present (closely spaced setae along the apex of the elytra).

Among the members of Brachinina, all combinations of elytral pubescence exist, and the epipleura are always pubescent. These patterns of elytral pubescence are described in detail in Section 4.41. The apical fringe is absent in Brachinus subgenera Metabrachinus and Aploa, but is densely pubescent in members of Brachinus viridipennis Dejean, and is setiferous with long widely spaced setae in members of

Brachinus crepitans (Linné).

The amount of head and pronotum pubescence varies considerably among the species of Brachinida. The members of Mastax are densely pubescent to glabrous; Pheropsophus, Pheropsophidius, and Aptinus are sparsely setiferous; Brachinus are glabrous to densely pubescent; and Styphlomerus and its allies are densely pubescent.

The pubescence of the cephalic appendages is quite variable throughout the group. All members of the Crepidogastrini have dense pubescence on every appendage from base to apex. The members of Aptinina, Brachinina, and Mastacina have dense pubescence on the outer articles of the appendages. This pubescence gradually increases in density from the base to the apex. The members of Pheropsophina are the least pubescent of the entire group, with only stiff spines or setae basally, and sparse pubescence distally. In these beetles and those of the preceding three subtribes, the antennal pubescence is fairly dense on article three, and very dense on articles four to eleven. The mandibular scrobes of the members of Crepidogastrini and Brachinina are plurisetose, while those of the other groups are unisetose. Besides the short pubescence, these two groups of beetles also have the single large seta in the scrobe.

The venter of the prothorax is densely pubescent medially in members of Crepidogastrini, and is less densely pubescent toward the proepipleura. In the other groups, the prosternum usually has numerous long and scattered setae, with the proepisterna, proepimera, and proepipleura variably setiferous. The venter of the mesothorax, metathorax, and abdomen are pubescent in all groups.

The legs of all groups, except the members of Pheropsophina, are

pubescent. In these beetles the setae are scattered and spine-like, forming rows in members of some species.

Major setae occur in numerous places on bombardier beetles. Members of all groups have a single long seta in the mandibular scrobe, and a single pair of supraorbital setae. In Mastax, however, a second "pseudosupraorbital " pair of setae are behind the eye, laterad on the vertex. With the exception of some crepidogastrines, all groups have one pair of lateral pronotal setae. The exceptions are members of Tyronia, Crepidolomus, and Crepidogastrillus which have a second pair of lateral setae in front of the hind angles. In Crepidogastrinus, a series of spine-like setae occur along the lateral margins of the pronotum from base to apex.

The major setae of the elytra are in the bottom of depressions between costae, in interval 8, and along depression 1 near the scutellum. Interval 8 and depression 1 have umbilicate punctures, each with a long seta, while the depressions have smaller punctures with setae of variable length, depending upon the species. The umbilicate series in depression 8 is continuous in all groups, except in members of Crepidolomus extimus (Jeannel). Basilewsky (1959) indicates this species has members with the umbilicate series divided into 8 setae anteriorly and 8 posteriorly.

The middle and hind coxae, hind trochanter, and the abdominal sterna 2-5 bear "ambulatory setae." The number and location of these long and widely spaced setae varies with the species.

The setae of the tarsi are discussed in detail under Section 3.7, so they will not be considered at this point.

3.3 Head

3.31 Cranium

The general shape of the cranium is the same for all groups. In the few species with reduced eyes, and in the blind members of *Brachynillus*, the head is much narrower.

3.32 Eyes

Only one species, *Brachynillus varendorffi* Reitter, is known to have all members eyeless. Another species, *Tyronia caeca* Basilewsky, has all its members with highly reduced eyes with only a few facets, and according to Jeannel (1926), beetles with this type of eye are functionally blind. The eyes of members of *Brachinulus viettei* Basilewsky and *Brachinus pygmaeus* Dejean are very small, and hardly protrude beyond the sides of the head. These species must be considered as somewhere between Jeannel's "Type aptère" and "Type anophthalme," since they are "depigmented" in comparison to the normal bright colors of the other bombardier beetles. All other brachinines have fully functional eyes, although some *Brachinoaptinus* members have a reduced numer of facets.

3.33 Antennae

In general, the antennae of members of Brachinina are filiform, while those of Crepidogastrini are moniliform. Some groups of the Brachinina, however, have antennae with shortened articles, as in the members of *Mastax*, *Styphlodromus*, *Styphlomerinus*, and *Styphlomerus*. In these groups, articles 5-11 are almost square, slightly longer than wide, or moniliform. All groups have a rather robust scape, a very

short pedicel, and articles 3-11 are subequal. In members of Neobrachinus, Aptinomorphus, and some Asian and African Brachinina, the third article is elongate. The length of that third article may prove to be useful in the identification of Brachinus subgenera (defined on the basis of the internal sac of the male genitalia), when the Old World fauna is better known. Bell (1960) used this antennal character successfully in the genus Chlaenius to distinguish taxa.

3.34 Labrum

The labrum of all groups is essentially rectangular and slightly emarginate at the anterior margin. Six or eight setae occur along the anterior margin. There are six setae in members of Brachinina, Pheropsophina, and some Aptinina, and eight setae in Mastax, Crepidogastrini, and some Aptinus.

3.35 Mandibles

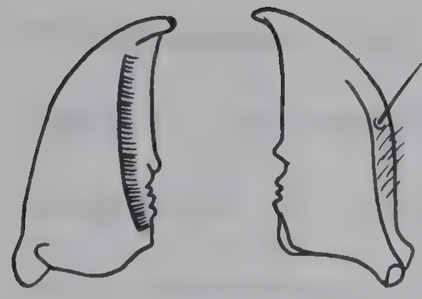
There is great divergence in the characteristics of the mandibles of the Brachinida members. One group, the Mastacina, has members with highly aberrant mandibles (fig. 6). These mandibles are no doubt adapted to some specialized feeding behavior, and are correlated with other modifications of the mouthparts (see below). The members of Mastax have flat, falciform mandibles, each with a large bifid retinaculum. The scrobe is absent, but the scrobal seta remains. The basal margin is densely setiferous, as is the ventral groove. This type of mandible looks very similar to larval mandibles in other bombardier beetles, and may represent a neotenous condition in these

beetles. Jeannel (1926) has suggested neoteny for other characteristics in the Trechini.

All other groups have mandibles which are basally trigonal and apically subfalciform. All possess scrobes which are plurisetose in Brachinina (figs. 1, 8) and Crepidogastrini (fig. 7) members, and unisetose in Aptinina (figs. 2, 3) and Pheropsophina (figs. 4, 5) members. Members of all species possess a setiferous ventral groove, and in addition the members of Pheropsophina possess a brush of setae on the basal margin. There appears to be interspecific variability in the teeth of the cutting edge, but I have not studied this in detail. Intergeneric mandibular variation occurs as follows: Aptinina members have small rounded cusps, two terebral and one retinacular; *Styphlomerus* members have an elongate and ridge-like retinaculum; Crepidogastini members have a single sharp terebral tooth and a retinacular ridge; Pheropsophina members have two types, the first is found in the primitive *Pheropsophidius*, and is a small square swelling on the terebrum, while the second is found in members of all other subgenera, and consists of a single terebral tooth and a bifid retinacular tooth; Brachinina members have the most complex pattern of mandibular teeth found in the bombardier beetles, consisting of several teeth on both the terebral and retinacular edge.

Figs. 1-8. Right mandible, ventral and dorsal aspect. 1. *Aploa nobilis* Dejean, Chad, Africa. 2. *Styphlomerus ?ciliatus* Liebke, Garamba, Congo, Africa. 3. *Aptinus bombarda* Illiger, Europe. 4. *Pheropsophidius rivieri* Demay, Ciudad Bolivar, Venezuela. 5. *Pheropsophus ?bimaculatus* (Linné), Mysore, India. 6. *Mastax ?hargreavesi* Liebke, Abakaliki, Nigeria. 7. *Crepidogaster caffra* Peringuey, Cape Point, South Africa. 8. *Brachinus phaeocerus* Chaudoir, Lake Roberts, New Mexico. Fig. 9. Right maxilla. dorsal aspect, *Aploa nobilis* Dejean, Chad, Africa.

Accompanying scale lines equal 1.0 mm.



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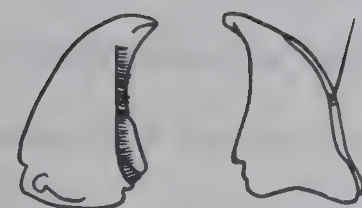

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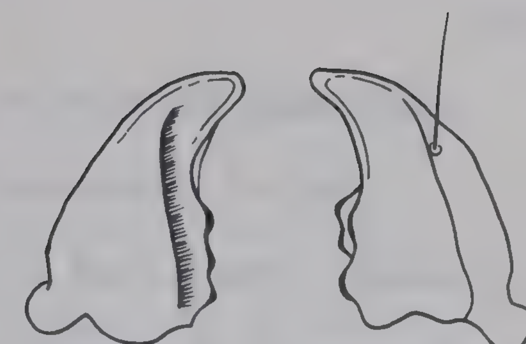

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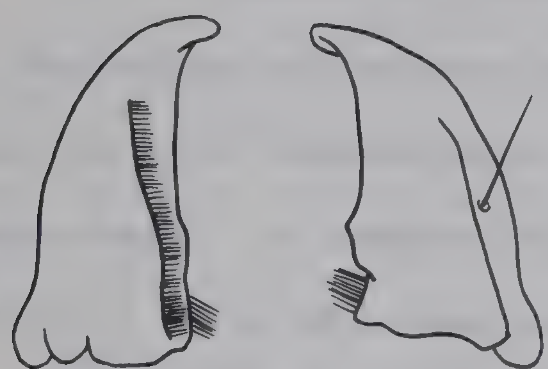

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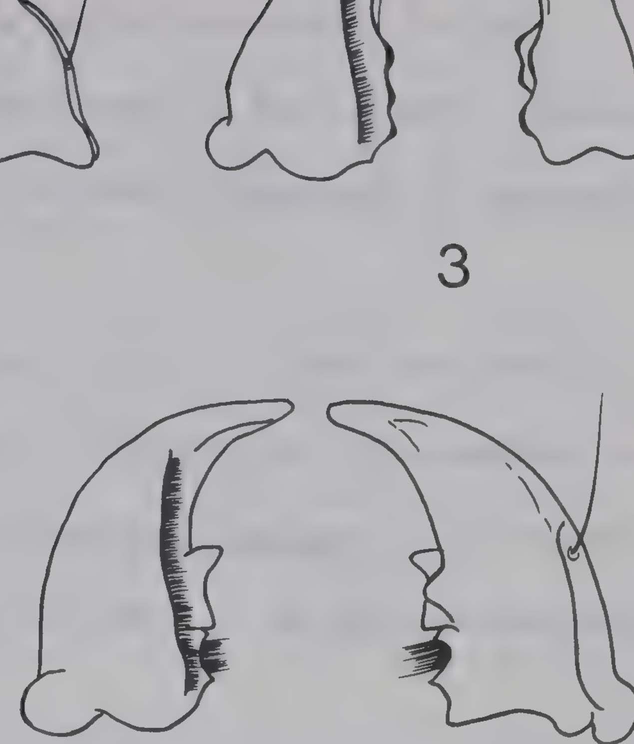

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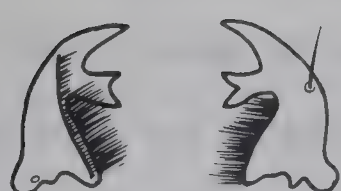

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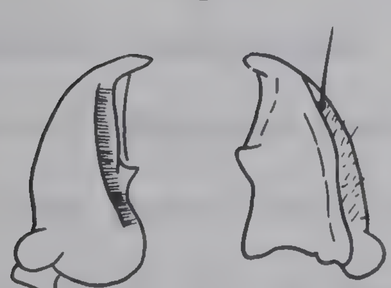

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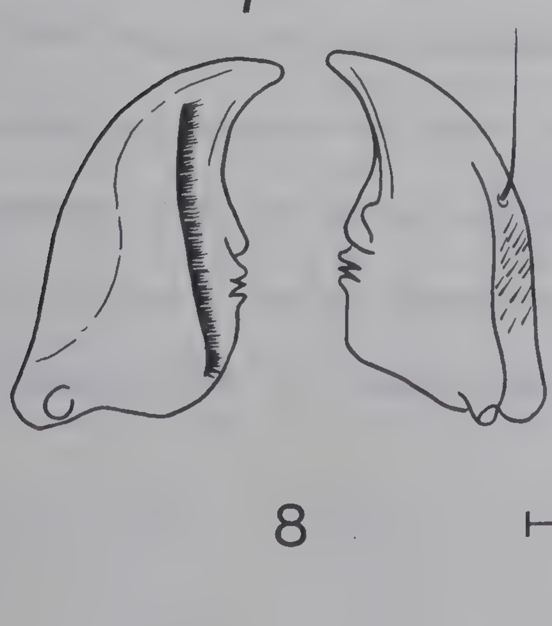

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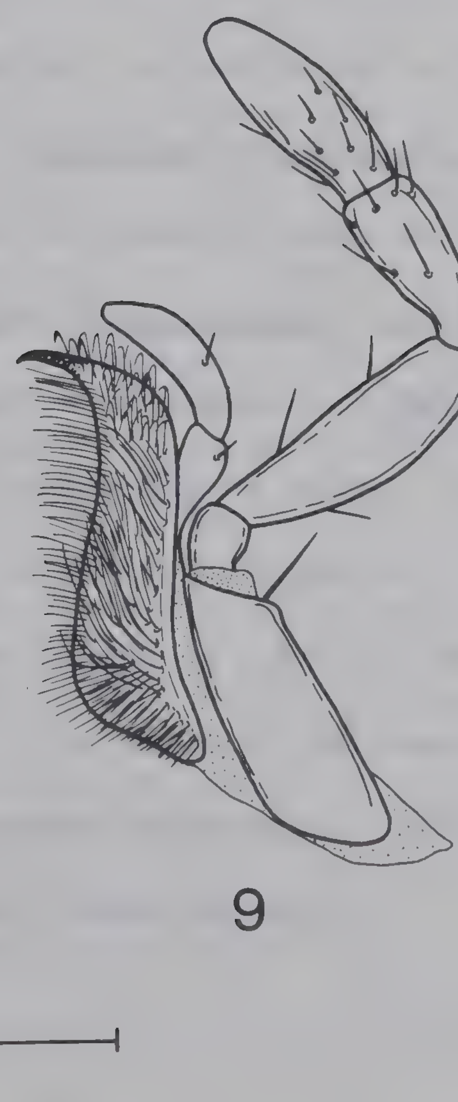

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Pheropsophina (fig. 12) this area is globose as in other bombardier beetles. In some cases, interspecific variation occurs in the disposition of ligular setae and in the shape of the central convexity. These characteristics can be used for reliable diagnosis of particular species.

In most members of Crepidogastrini (fig. 11), the last article of the palpus is securiform or globose, or almost so. In members of most Old World Pheropsophina (fig. 14) and Brachinulus, it is narrowly wedge-shaped. In members of Mastax (fig. 10), it is globose-attenuate, otherwise it is subcylindrical.

The mentum is generally the same in all groups. It is toothed in members of Aptinina (figs. 16, 17) and Mastax (fig. 10), but in the latter it may be a result of the deep central pit surrounded by setae. The lateral lobes of the mentum are usually acute, but in members of Mastax they are broadly rounded. The deep pit in the center of the mentum is found in all members of Mastax, Brachinus costipennis, and Brachinus longipalpis. A shallower sulcus is found in some members of European Brachinus species and in Brachinus (Neobrachinus) mobilius. Two deep lateral pits are found in the mentum of members of Brachinus sallei (fig. 20) of Mexico and Brachinus scotomedes of Japan. Jeannel (1926) suggested that similar structures in Trechini might be acoustical organs and that the innervation should be traced. No one, however, has yet investigated these pits. The setae of the mentum provide many useful characteristics for species diagnosis. The submentum and its setae also provide useful characteristics.

3.36 Maxillae

The maxilla (fig. 9) varies little throughout the bombardier beetles. The cardo is small. The stipes is about three times the length of the cardo. The galea is palpiform and two-articled, and the lacinia is falciform and sharply pointed at the apex. The dorsal surface of the lacinia is densely clothed with long setae. Only in members of *Mastax* is the acute apex of the lacinia slightly reduced. The palpus is composed of four articles, the last of which is subcylindrical, except in some members of the Old World Pheropsophina and *Brachinulus* (wedge-shaped), *Mastax* (globose-attenuate), and some Crepidogastrini (securiform, globose).

3.37 Labium

The characteristics of the labium are quite divergent throughout the bombardier beetles. The ligula probably represents the fused glossae and paraglossae. This is most evident in members of *Mastax* (fig. 10) in which the membranous setiferous lateral lobes (=paraglossae) are twice the size of the convex median sclerotized lobe (=fused glossae). In members of *Mastax* this median lobe generally has three or more long setae. The members of Crepidogastrini (fig. 11) possess a very small ligula which has a convex medial sclerotized area and small membranous lateral lobes, each with two or more setae. The members of Aptinina (figs. 16, 17) and Brachinina (figs. 13, 15) are generally the same, except the dorsal surfaces of the lateral lobes are setiferous. In the members of the Old World Pheropsophina (fig. 14), the venter of the ligula is carinate, but in New World

Figs. 10-17. Labium, mentum, and gula, ventral aspect. 10. Mastax ?hargreavesi Liebke, Abakaliki, Nigeria. 11. Crepidogaster caffra Peringuey, Cape Point, South Africa. 12. Pheropsophidius rivieri Demay, Ciudad Bolivar, Venezuela. 13. Brachinus phaeocerus Chaudoir, Lake Roberts, New Mexico. 14. Pheropsophus ?bimaculatus (Linné), Mysore, India. 15. Aploa nobilius Dejean, Chad, Africa. 16. Styphlomerus ?ciliatus Liebke, Garamba, Congo, Africa. 17. Aptinus bombarda Illiger, Europe. Accompanying scale lines equal 1.0 mm.

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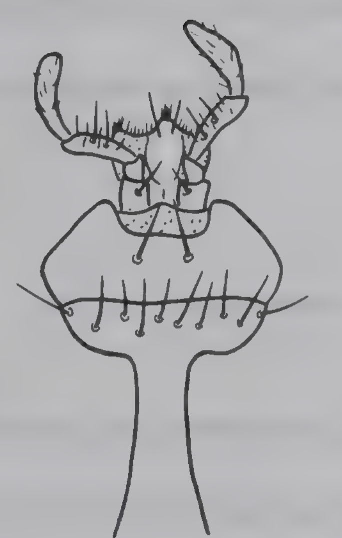

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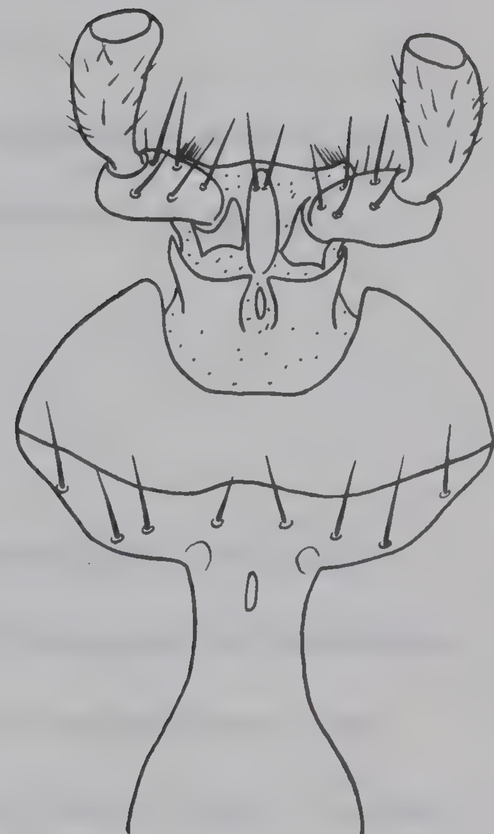

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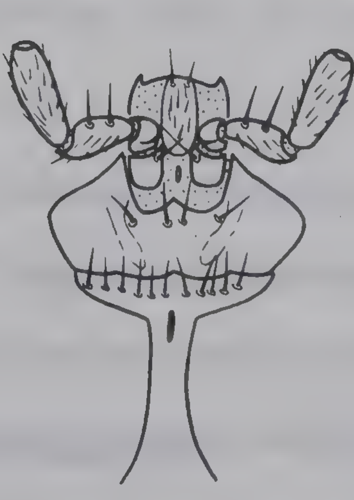

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The submentum is slightly variable among members of the Brachinida, particularily the sides that conceal the bases of the cardines (figs. 10-17). In members of Mastax, Brachinus costipennis (fig. 18), and Brachinus longipalpis, the submentum is very short. This shortening is concordant with the sulcate mentum.

The gular sutures are divergent in all groups except the crepidogastrines (fig. 11), in which they converge to the occipital groove, then diverge.

In summary, the characteristics of the head provide many useful criteria for phylogenetic considerations and taxonomic diagnoses at all categorical levels.

3.4 Prothorax

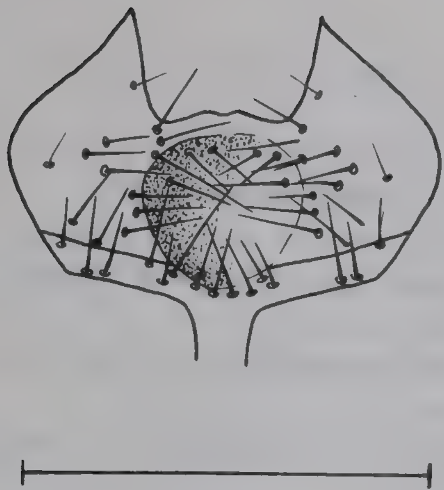
Externally the prothoraces of members of Brachinida are very similar (fig. 22). Internally, however, great divergence is exhibited in the structure of the coxal cavities. Both the uniperforate and biperforate conditions exist; that is, one or two holes enter the body cavity for the passage of muscles. Biperforate coxal cavities (fig. 25) occur in members of Crepidogastrini, Mastacina, and Pheropsophina, while the uniperforate condition (fig. 24) occurs in the Brachinina and Aptinina. The remnants of a bridge (fig. 23) are quite evident in members of Brachinus (sensu stricto), Brachynolomus, and Aptinina, but are almost absent in other Brachinus (Neobrachinus).

The proepimeron closes the procoxal cavity behind in all groups except in members of Protopheropsophus and Stenaptinus. In the members of the latter genus, the proepimeron barely reaches the prosternal process, and in some specimens there is a noticeable

gap. This variation might not have phylogenetic significance if it were not for the members of Protopheropsophus biplagiatus Chaudoir, which have a wide and consistent gap behind the coxal cavity. In most cases when the coxal cavities are closed behind, it is due to the proepimeron overlapping the lateral process of the prosternum. However, in Brachynolomus, Brachinoaptinus, Aploa, and some Cnecostolus, and Neobrachinus each lateral process of the prosternum forms a "socket" or "notch" into which the proepimeron inserts. Bell (1967) points this out as a generality for Brachinini, but he evidently examined members of Neobrachinus only.

The only other prothoracic character that shows intergeneric variation is the presence or absence of a propleural suture. Although the proepisternum and proepimeron are fused, a ridge runs the length of the fused sclerites in the area of juncture. This ridge occurs in the Crepidogastrini, Mastacina, and Old World Pheropsophina.

Figs. 18-21. Mentum and submentum, ventral aspect. 18. *Brachinus costipennis* Motschulsky, 12.2 miles south of El Banco, Durango, Mexico. 19. *Brachinus melanarthrus* Chaudoir, 5.0 miles northwest of Acayucan, Veracruz, Mexico. 20. *Brachinus sallei* Chaudoir, Cozumel Island, Quintana Roo, Mexico. 21. *Brachinus microamericanus* new species, Dundee, Mississippi. Fig. 22. Diagrammatic prothorax, left lateral aspect. Figs. 23-25. Anterior coxal cavities, ventral aspect. 23. *Brachinus crepitans* (Linné), Switzerland. 24. *Brachinus phaeocerus* Chaudoir, Lake Roberts, New Mexico. 25. *Pheropsophus ?bimaculatus* (Linné), Mysore, India. Fig. 26. Diagrammatic middle and hind coxae and metasternum, ventral aspect. Accompanying scale lines equal 1.0 mm. (pp = proepipleuron, pe = proepisternum, ps = prosternum).



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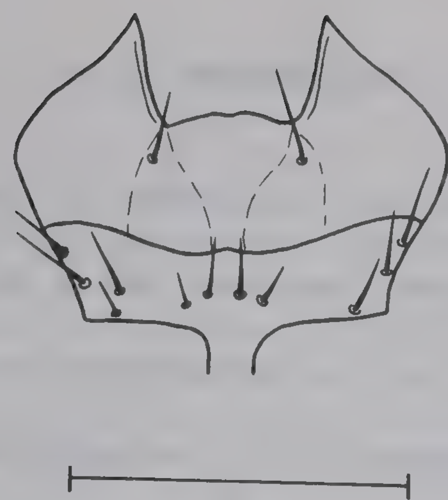

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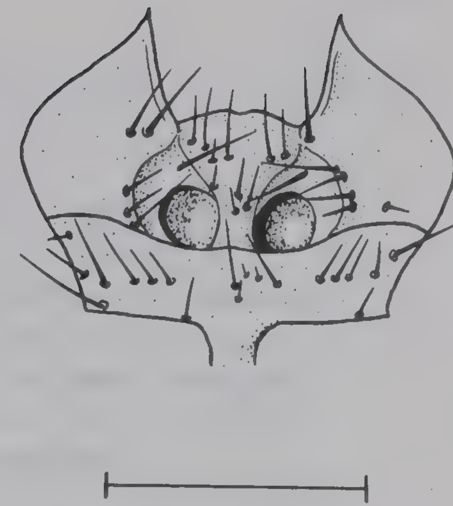

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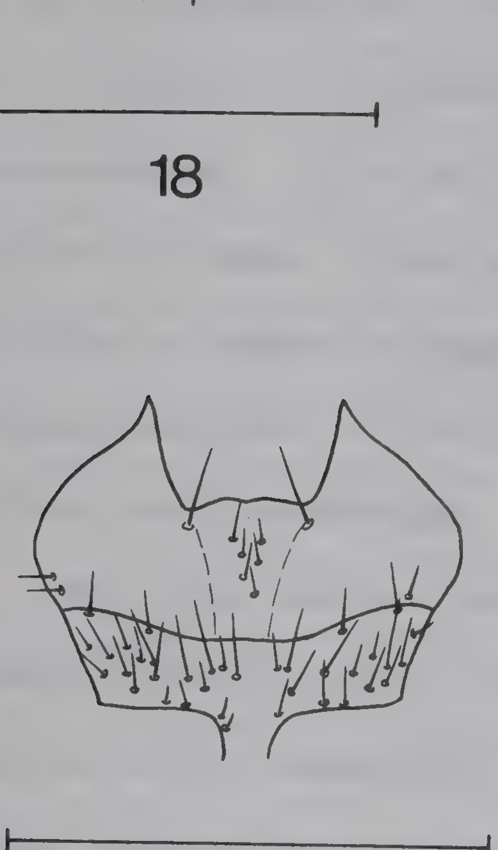

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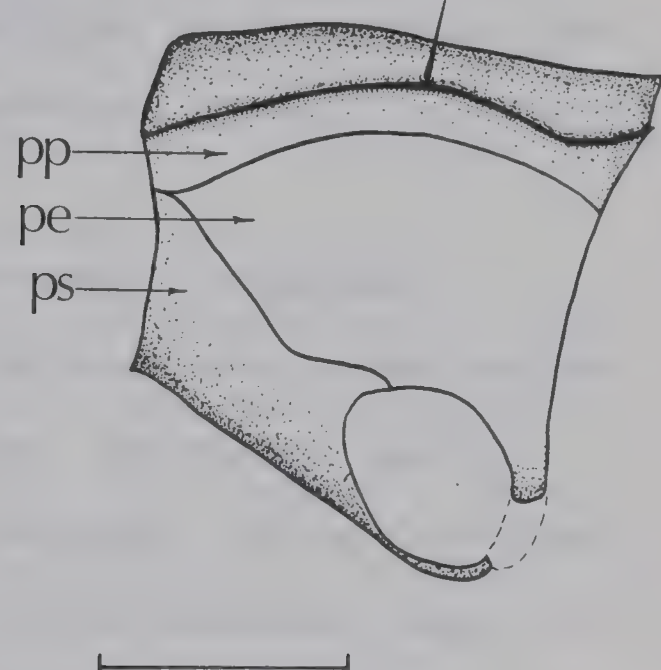

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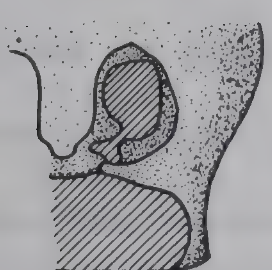

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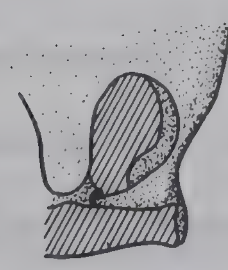

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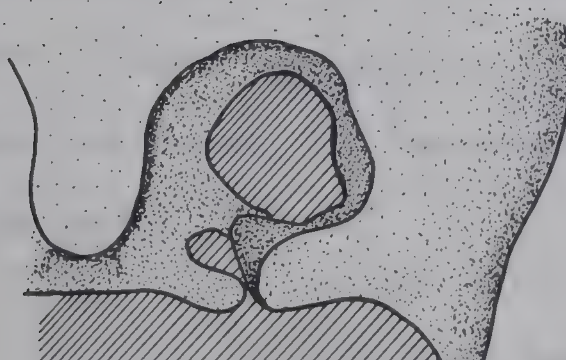

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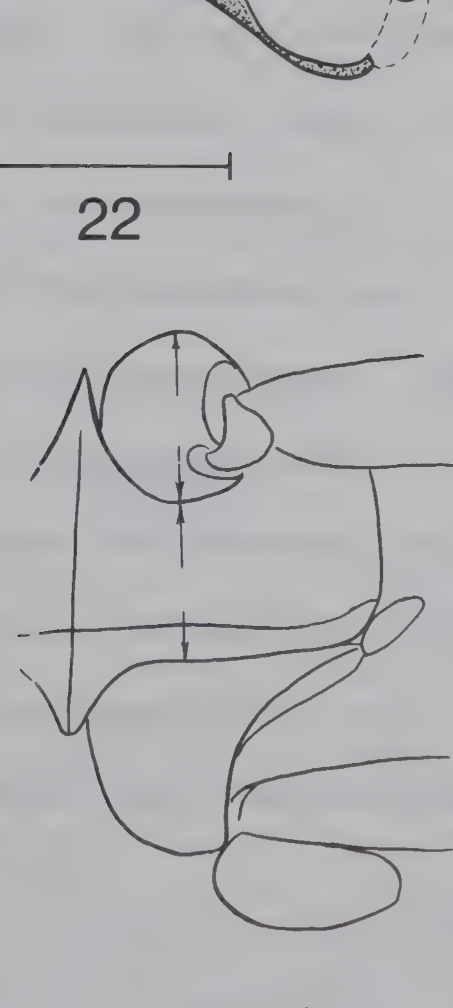

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3.5 Mesothorax

The mesothorax is usually unmodified externally throughout the members of Brachinida, with a few important exceptions. In members of the Crepidogastrini, the mesepimeron is lost or is very narrow, and is internal. The mesepisternum is in contact with the metepisternum. I discuss the importance of this character state in Section 3.6 under "flightlessness." The coxal cavities are conjunct-separate in members of Mastax, Pheropsophidius, and Pheropsophus, and conjunct-confluent in the rest of the bombardier beetles. Bell (1967) defines coxal terminology.

The elytra exhibit considerable intergeneric variation. Generally, each elytron is rectangular (or hemi-ovate in some wingless species) with a moderately wide epipleuron. The truncate apex is either perpendicular to the suture or is angulate. In the latter case, the length along the suture is shorter than the epipleural length. The costae of the elytra are present in all groups, but differently modified in some.. The members of the Old World Pheropsophina have carinate costae, separated by flat, macrosculptured depressions. The costae are narrow in Aptinomorphus, and wide in Stenaptinus and Pheropsophus (sensu stricto). The other bombardiers have rounded, low or moderately-high costae, alternating with the strial depressions. In members of some Brachinus, Styphlomerus, and Crepidogastrini, the costae are absent, but the erect "depression setae" mark the location of the striae.

3.6 Metathorax

The metathorax is similar in all bombardiers, except in members of

Mastax. This aberrant genus has members with the anterior metasternal process broadly rounded, rather than acute as in other bombardiers. Further, the members of this genus have the metacoxal cavities lobate-separate, rather than lobate-confluent as in other bombardiers.

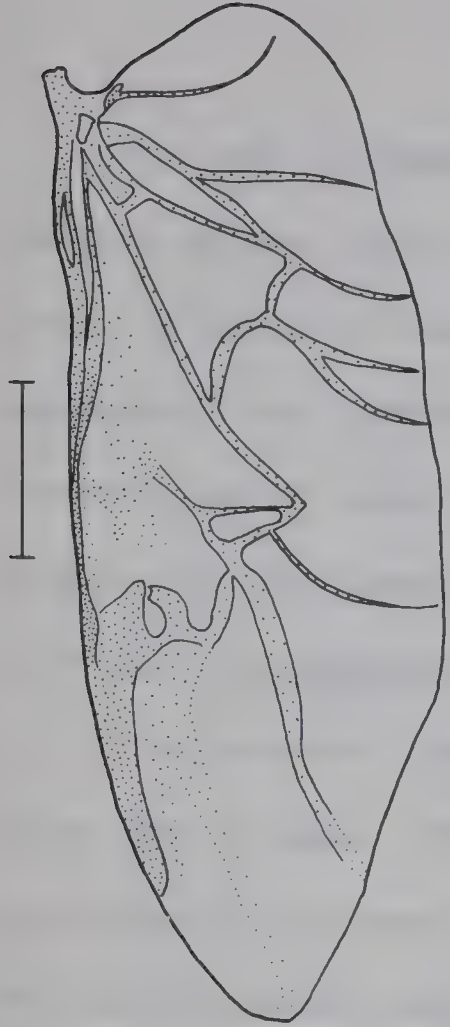
In members of wingless Brachinida species, or those becoming flightless (not wing dimorphic), there is a reduction in the length of the metasternum and metepisterna. In all cases where there has been wing reduction or loss of flight (even when not necessarily from reduction of wing membrane), the length of the metasternum behind the mesocoxa is subequal to or shorter than the diameter of the mesocoxa (fig. 26). The metepisternum has not become square as in some _Pterostichus_ (Ball, 1960; Hacker, 1968), except in beetles with wings entirely absent as in members of _Aptinus_ and Crepidogastrini. With the reduction in the length of these "flight components," the lobe of the metepimeron becomes larger, especially in _Aptinus_. In species which apparently have been flightless for a long time, such as the members of Crepidogastrini, the mesepimeron disappears, at least externally.

I believe that the relative ages of wingless species of bombardiers (and possibly other carabids) may be determined by comparisons of metathoracic structures. Hypothetically, the longer a species has been flightless, the shorter the metasternum, metepisterna, and wings become, the more sloping the humeri become, and the larger the lobe of the metepimeron becomes. Ultimately, the elytra fuse along the suture, but this does not occur in bombardier beetles. Of course the reduction probably begins with wing dimorphism as described by Lindroth (1945, 1963) and Darlington (1936, 1943), but after all

members of the species have become flightless, then reduction in the mesothoracic and metathoracic flight components begins, and a building-up of thoracic "ambulatory components" takes place.

Most groups of bombardier beetles have some wingless members, but I have not yet seen or heard of any wingless members of Mastax or of Styphlomerus and its allies. Among those bombardier beetles with wings (figs. 27-32), there is great similarity in the venation and wing-folding pattern. Both are clearly "caraboid" in nature (see Forbes, 1926), except in members of Mastax. This aberrant group has all the wing veins reduced to vague sclerotized fields on the membrane. The oblong cell has almost disappeared, and the wedge cell, and the first and second anal complexes are absent. Further, the wing is rounded apically, rather than being acute as in the other bombardier groups.

Figs. 27-32. Left wing, dorsal aspect. 27. Styphlomerus ?ciliatus Liebke, Garamba, Congo, Africa. 28. Mastax ?hargreavesi Liebke, Abakaliki, Nigeria. 29. Brachinus phaeocerus Chaudoir, Lake Roberts, New Mexico. 30. Pheropsophus ?bimaculatus (Linné), Mysore, India. 31. Aploa nobilis Dejean, Chad, Africa. 32. Brachinus imporcitis new species, Pinal Creek, Arizona. Accompanying scale lines equal 1.0 mm.



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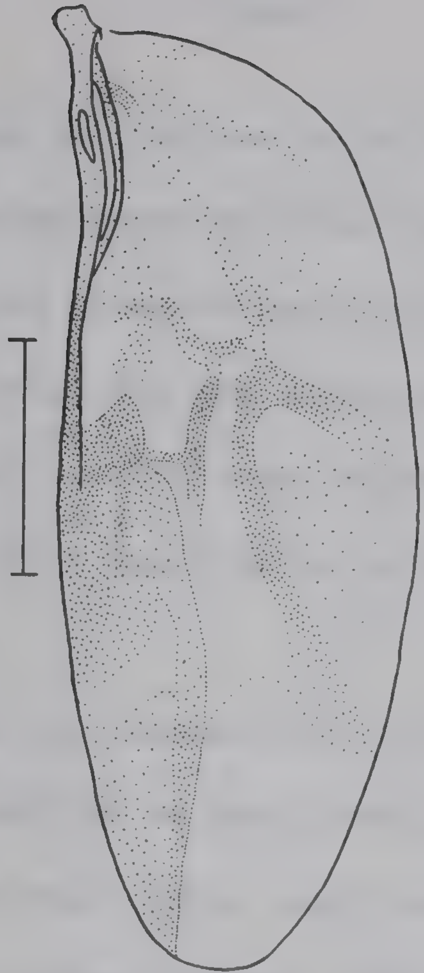

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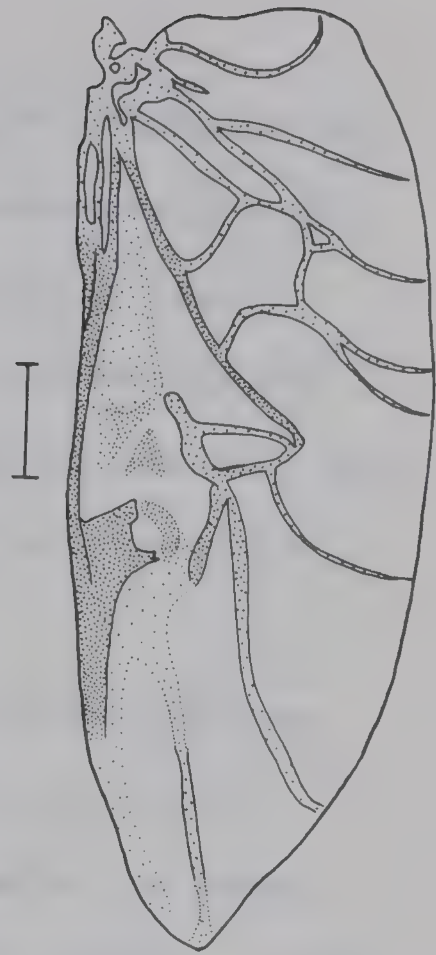

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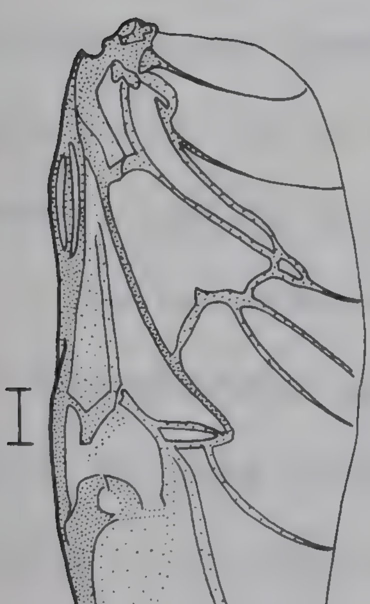

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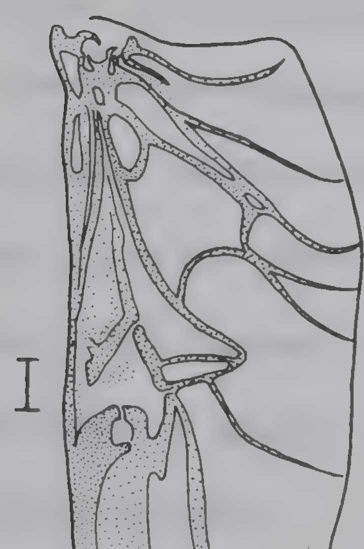

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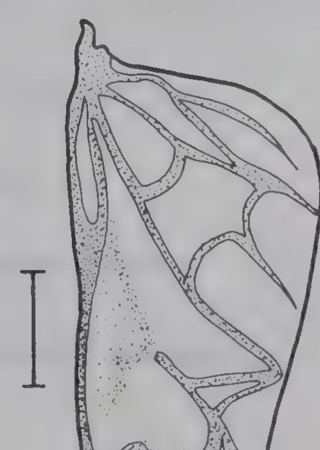

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3.7 Legs

The legs of bombardier beetles are quite similar throughout the various groups, but the pubescence and setae vary interspecifically. Only the anterior tibiae and anterior male tarsi offer obvious characters for taxonomic diagnoses and phylogenetic considerations. Possibly after enough study of additional representative material, the middle and hind legs may offer good characteristics in some groups (but not in Neobrachinus).

The anterior tibia has an antennal comb one third the distance from apex to base. The position of this comb, and the relative positions of its two associated spurs, have been used as the bases of some proposed classifications (Jeannel, 1941; Bell, 1967). In the bombardier beetles, the proximal spur (figs. 33-39) is located on the upper edge of the comb, either internally (Aptinina, Crepidogastini), intermediately positioned (Aploa, Brachinoaptinus, Pheropsophus), or externally. It is absent in members of Mastax (fig. 40). The distal spur is located at the tibial apex, behind the tarsal insertion.

The vestiture of the male anterior tarsal articles is intergenerically quite diverse. The members of Crepidogastrini (fig. 50) have circular pads of setae spongy in appearance beneath either two or three basal tarsal articles.

Figs. 33-40. Right front tibia of male, lateral aspect. 33. *Brachinus phaeocerus* Chaudoir, Lake Roberts, New Mexico. 34. *Pheropsophus* ?*bimaculatus* (Linné) Mysore, India. 35. *Pheropsophidius rivieri* Demay, Ciudad Bolivar, Venezuela. 36. *Aptinus bombarda* Illiger, Europe. 37. *Aploa nobilis* Dejean, Chad, Africa. 38. *Crepidogaster caffra* Peringuey, Cape Point, South Africa. 39. *Styphlomerus* ?*ciliatus* Liebke, Garamba, Congo, Africa. 40. *Mastax* ?*hargreavesi* Liebke, Abakaliki, Nigeria. Accompanying scale lines equal 1.0 mm.

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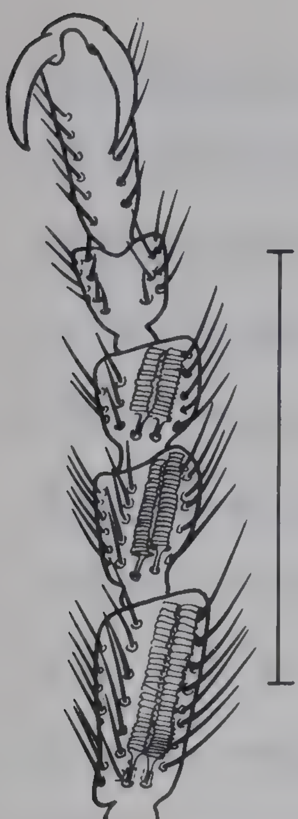
Figs. 41-47, 49, 50. Right front tarsus of male, ventral aspect. 41. Brachinus immaculicornis Dejean, France. 42. Brachinus phaeocerus Chaudoir, Lake Roberts, New Mexico. 43. Aptinus bombarda Illiger, Europe. 44. Pheropsophus ?bimaculatus (Linné) Mysore, India. 45. Pheropsophidius rivieri Demay, Ciudad Bolivar, Venezula. 46. Aploa nobilis Dejean, Chad, Africa. 47. Styphlomerus ?ciliatus Liebke, Garamba, Congo, Africa. 49. Mastax ?hargreavesi Liebke, Abakaliki, Nigeria. 50. Crepidogaster caffra Peringuey, Cape Point, South Africa. Figs. 48, 51, 52. Female ovipositor, ventral aspect. 48. Styphlomerus ?ciliatus Liebke, Garamba, Congo, Africa. 51. Stenaptinus ?kolbei Hubenthal, Cameroon, Africa. 52. Crepidogaster caffra Peringuey, Cape Point, South Africa. Accompanying scale lines equal 1.0 mm.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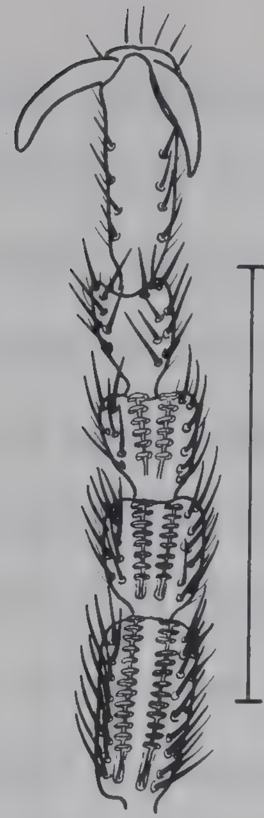
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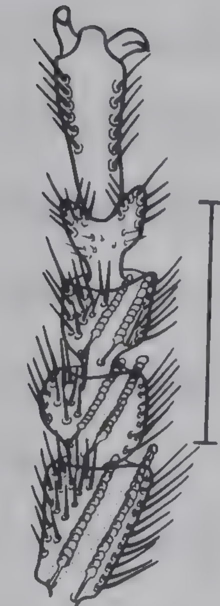
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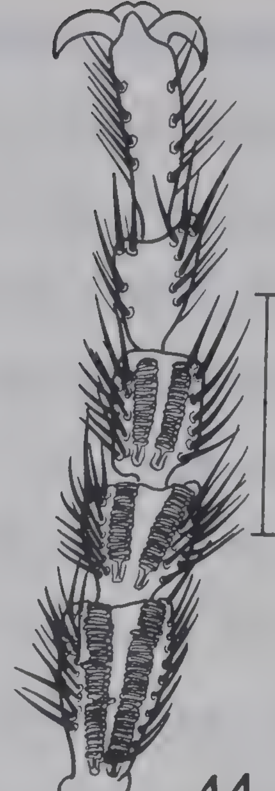
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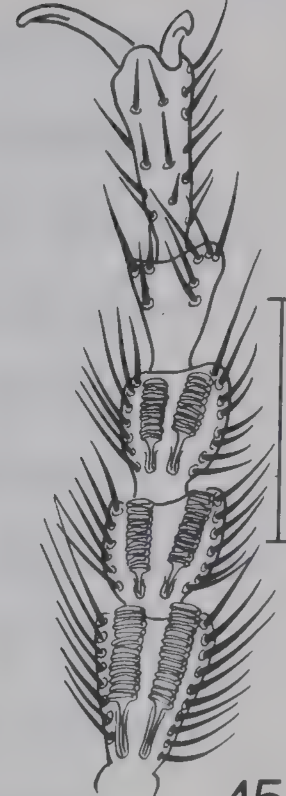
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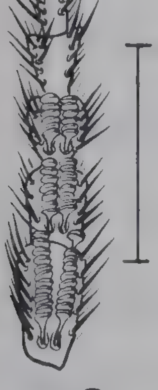
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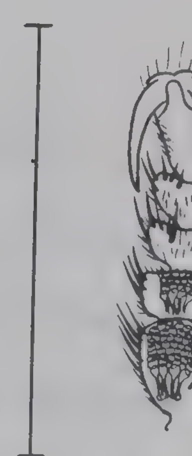
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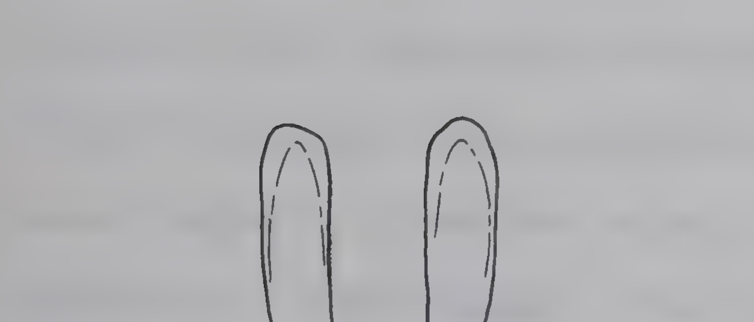
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An Indian species, Tyronia humerata (Chaudoir), has members with three articles with pads of vestiture, while the African Tyronia kivuensis Basilewsky has only two articles with vestiture. Members of Mastax have each of the two basal articles bearing two parallel rows of spatulate setae (fig. 49). The rows are symmetrically arranged on the underside of the articles. This same two-rowed pattern is seen in some Brachinina (fig. 42), and in all Pheropsophina (figs. 44, 45), except that in the latter two groups three articles have the vestiture. In members of the Aptinina (figs. 43, 47) and some Brachinina (fig. 41), the two parallel rows are diagonally placed on the three basal asymmetrical tarsal articles.

3.8 Abdomen

The abdomen of the bombardier beetles exhibits very little variation. The females have seven visible abdominal sterna, while the males have eight. In the male the eighth sternum is divided into two lateral halves, while in both sexes the ninth tergum is modified into twin "crepitation chambers," separated by a median keel. At the base of the keel, on either side, lies the outlet from the mixing chamber of the crepitating mechanism. When the mechanism is not being fired, the eighth tergum overlies the ninth. During crepitation the ninth tergum is telescoped caudally from under the eighth tergum, exposing the twin chambers. Each chamber consists of a smooth "L-shaped" trough bordered internally by the median keel, and bordered caudally by the up-turned apex of tergum nine. The foot of the "L" lies transversely at the base of the upturned apex of tergum nine. This construction allows the beetles to "aim" the chemical components of

its irritant toward the predator. Eisner (1958) has studied the directional aspects of this defensive spray, and he shows it can be aimed. I have experienced the aiming capabilities of these beetles while collecting them and while observing them in the laboratory. The extensible abdomen and truncate elytra allow free movement of the abdominal apex for aiming.

3.9 Genitalia

3.91 Female ovipositor and *bursa copulatrix*

Tanner (1927) discussed the family characteristics of carabid female genitalia. The bombardier beetles fit the basic description Tanner gives, with the exception of *Mastax* and *Crepidogaster*. In members of *Mastax* (fig. 62) there are two lateral, elongate sclerites in the position Tanner illustrates for the ninth sterna. In the position Tanner illustrates for the tenth sternite behind the bursal opening, there are two small transverse rods. Further, members of *Mastax* have a single seta on the coxite that exceeds the length of the stylus. In members of *Crepidogaster* (fig. 52), the coxite and stylus are fused and articulated with the valvifer. Peculiarly, the base of the valvifer is plurisetose.

The members of Aptinina have the normal caraboid three piece ovipositor. In *Aptinus* members (fig. 58), the apical-medial corner of the valvifer is plurisetose, while in members of *Styphlomerus*, *Styphlomerinus*, and *Styphlodromus* (fig. 48), the apical edge of the valvifer has several flattened spine-like setae. The styli of the Aptinina members are strongly curved blades, which are usually

acute apically. The members of the remaining genera have variously modified styli, depending upon the species. In the members of Pheropsophina (figs. 51, 59, 61), the stylus blade is variously modified among the subgenera. Pheropsophus (sensu stricto) members have very elongate and narrow styli, some with microspinules along the inner edge (fig. 61). In Stenaptinus members, the styli are long and spatulate (fig. 51). In the members of Pheropsophidius, they are similar to those in members of Brachinus, but lack the setae (fig. 59).

The various members of Brachinus and Aptinoderus have the normal carabid three piece ovipositor. The stylus is flattened and triangular, but varies considerably between the species. The members of Brachinus have a single small seta on the ventral side near the apex of the spatulate stylus.

The female members of Aptinus (fig. 55) are the only Brachinida which possess bursal sclerites. The entire walls of the bursa are thinly sclerotized in a laminate fashion. A single large rod-like sclerite is dorsal to the entrance of the bursa. Laterad, near the base of this rod on the wall of the bursa, is a large and concave sclerite. At this point the entire bursa is transverse, with a large forked sclerite in a pouch near the concave sclerite.

Fig. 53. Male genitalia of Mastax ?hargreavesi Liebke, Abakaliki, Nigeria, lateral aspect. Fig. 54. Ventral aspect of same. Fig. 55. Bursal sclerites of female Aptinus bombarda Illiger, Europe, dorsal aspect. Fig. 56. Male genitalia of Aptinus bombarda Illiger, Europe, lateral aspect. Fig. 57. Dorsal aspect of same. Figs. 58-62. Female ovipositor, ventral aspect. 58. Aptinus bombarda Illiger, Europe. 59. Pheropsophidius rivieri Demay, Ciudad Bolivar, Venezula. 60. Aploa nobilis Dejean, Chad, Africa. 61. Pheropsophus ?bimaculatus (Linné), Mysore, India. 62. Mastax ?hargreavesi Liebke, Abakaliki, Nigeria. Accompanying scale lines equal 1.0 mm. (go = gonopore, ds = dorsal sclerite, ls = lateral sclerites, tp = transverse pouch, bs = basal sclerite, sp = spermatheca, ov = oviduct)

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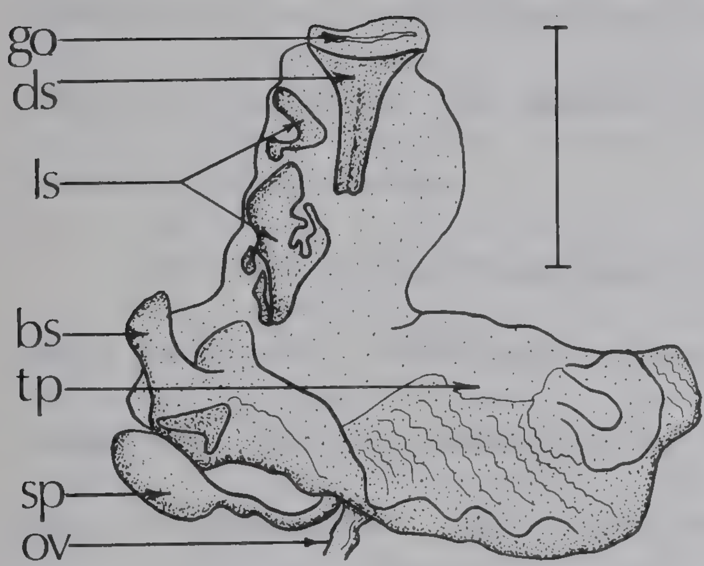

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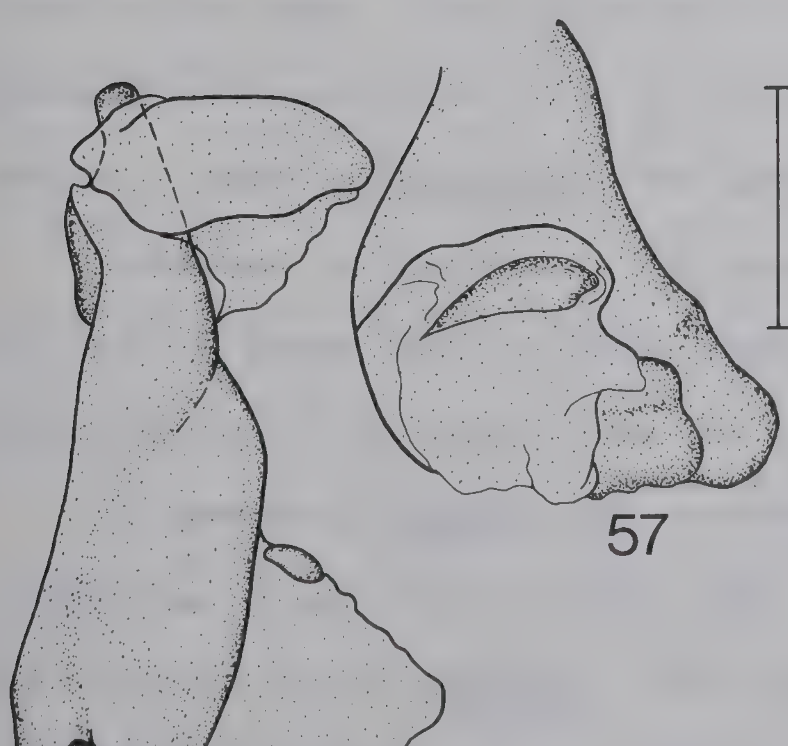

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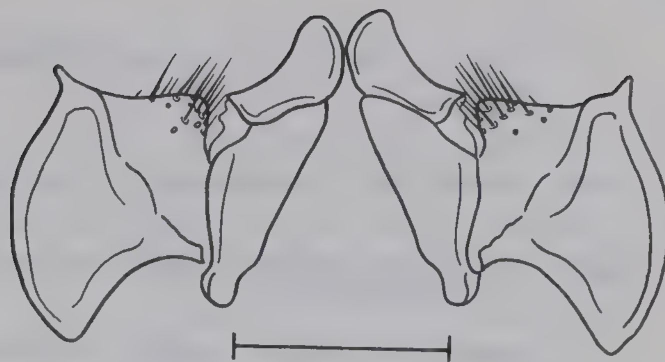

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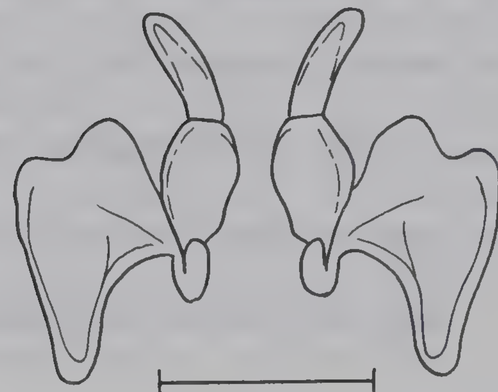

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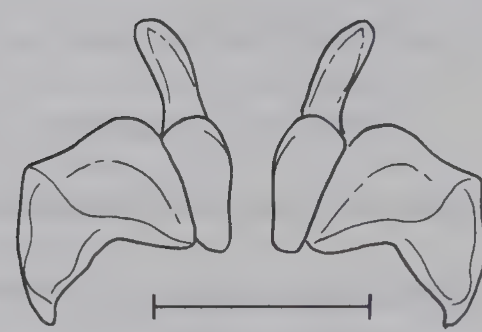

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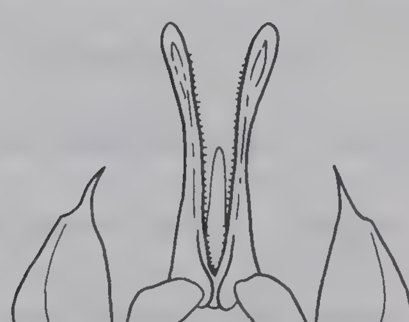

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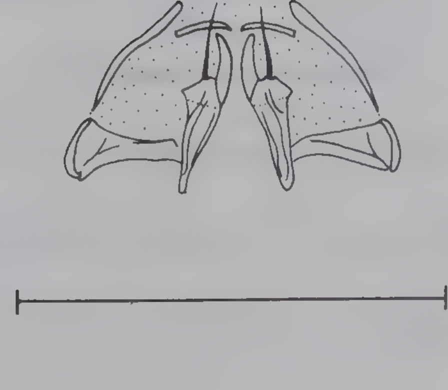

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3.92 Male genitalia

The male genitalia are interspecifically distinct, and they can be used to distinguish between species in at least Neobrachinus. They are composed of the following parts: median lobe, with the apex, shaft, ligule, basal bend, and basal portion; two parameres, (the left one large and the right one small) attached to the ventral corner of the basal portion of the median lobe; and an endophallus, which is a membranous sac containing the gonopore, which in turn may or may not provide attachment for various apical or subapical sclerites and microtrichial fields.

The members of Crepidogastrini possess a very primitive type of male genitalia. The median lobe is tubular, straight, or bent, sometimes with the shaft contorted. The parameres are not balteate, but are asymmetric. The left paramere is lobate, and is alongside the median lobe. The smaller right paramere is lobate and is held close to the shaft. The ligule of the shaft is absent. The endophallus is more than half the length of the median lobe, and in members of some Crepidogaster, the apex has microtricheal fields.

In members of Brachinini, the parameres are always balteate, the left is larger than the right, and both are wrapped around the basal portion of the median lobe and connected by a membrane.

The members of Mastax have the most aberrant median lobe and endophallus of all the Brachinida (fig. 53). The apex and shaft are similar to some Bembidion. The endophallus possesses a coiled ribbon-like sclerite, as well as one basal and one apical sclerotized plate. The parameres are smaller than in any other group, and they

tightly adhere to the base of the basal portion of the median lobe.

The remaining groups have "typical" brachinine genitalia with balteate parameres, a more or less tubular median lobe, and generally a moderate-sized endophallus. Some of these groups have microtrichia or sclerites on the internal sac. The members of Pheropsophus (fig. 69) and Pheropsophidius (figs. 437-442) have fields of microtrichia on a very long endophallus. Styphlomerus members which I have seen have a shorter endophallus, but still with microtrichia (but I have seen very few examples). Aptinus members have very contorted median lobes with a very short endophallus. The endophallus has one basal and two apical sclerites. Although I have not studied Aptinus males and females *in copula*, I believe there is a definite correlation between the female bursal sclerites, and the male median lobe. A study of this relationship might prove fruitful.

Within the genus Brachinus, there have evolved many types of endophallic sclerites. The members of Neobrachinus, Brachynolomus, Cnecostolus, and some African lineages, have developed an apical sclerite surrounding the gonophore. Snodgrass (1935) has termed this sclerite the "virga." The members of Brachinoaptinus, Brachinus (*sensu stricto*), Metabrachinus, other African lineages, and at least one Oriental lineage, do not have any sclerites on the endophallus. The members of one Oriental lineage have a long endophallus with a tube at the apex which bears microtrichia. The members of Aploa, and those of at least one west African lineage, have a subapical endophallic sclerite. The variation and homologies of these virgae and sclerites are extremely important aids for persons attempting to understand the relationships and hence, the dispersal movements

of the members of the genus Brachinus. Because of the extreme similarity in the external features of these beetles, the genitalic diversity often must be studied carefully to determine the species differences (see also Section 4.5).

Figs. 63-70. Male genitalia. 63. Crepidogaster caffra Peringuey, Cape Point, South Africa, ventral aspect. 64. Lateral aspect of same. 65. Aploa nobilis Dejean, Chad, Africa, ventral aspect. 66. Lateral aspect of same. 67. Styphlomerus ?ciliatus Liebke, Garamba, Congo, Africa, ventral aspect. 68. Lateral aspect of same. 69. Pheropsophus ?bimaculatus (Linné), Mysore, India, ventral aspect. 70. Lateral aspect of same. Accompanying scale lines equal 1.0 mm.

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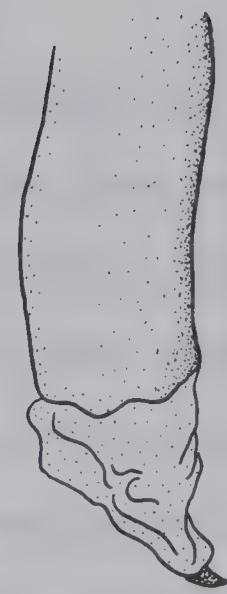

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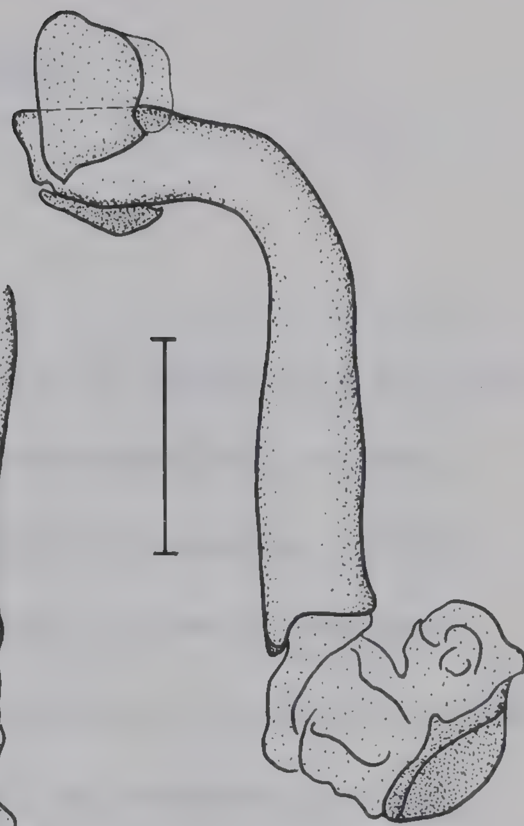

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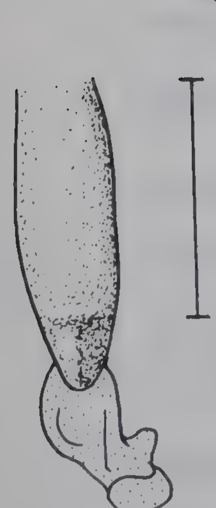

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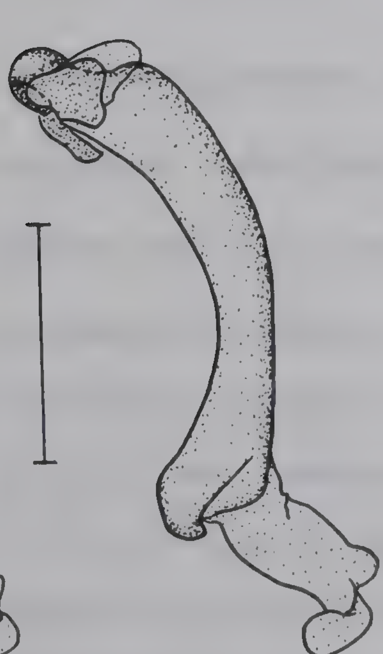

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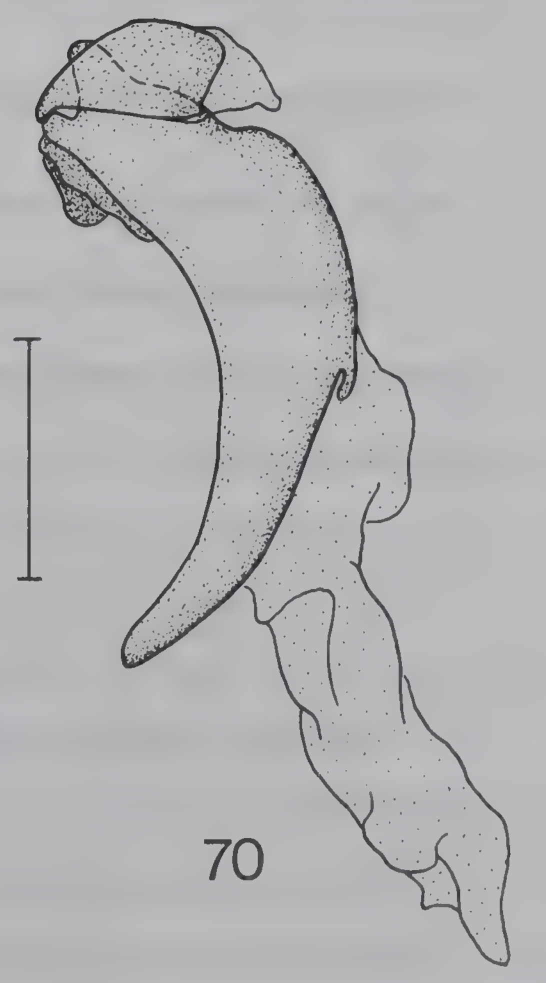

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4.0 TAXONOMY

4.1 Division Brachinida Bonelli

Brachinii Bonelli, 1809: tab. syn.

Brachinida Ball, 1960:164.

The following combination of characteristics is diagnostic of this Division of higher Carabidae: anterior tibia anisochaetous; middle coxae conjunct; lobe of metepimeron present; elytra truncate, costate, striae obscure; abdomen with seven or eight sterna normally exposed; outlets of the crepitating mechanism medial, in front of modified ninth tergum; ninth tergum modified into twin crepitating chambers in both males and females; male genitalia with an endophallus; parameres asymmetrical, the right minute, the left larger; cuticle of mature adult pliable.

This division includes the tribes Crepidogastrini and Brachinini.

4.11 Key to Tribes and Subtribes of the Division Brachinida

1. Mesepimera absent or almost so; ventral vestiture of male anterior tarsal articles spongy and pad-like; terminal palpal articles swollen, usually securiform; gular sutures convergent behind. . . . . (Crepidogastrini)

1'. Mesepimera present, broad, clearly visible; vestiture beneath male anterior tarsal articles consisting of two parallel rows of modified setae; terminal palpal articles subcylindrical or wedge-shaped; gular sutures divergent behind . . . . .Brachinini 2

2(1'). Hind coxae contiguous; metasternal process acute; middle coxae not widely separated; mandible with a scrobe; upper spur of anterior tibia present 3

2'. Hind coxae widely separated; metasternal process broadly rounded; middle coxae widely separated; mandible without a scrobe; upper spur absent . . . . . . Mastacina, new subtribe

3(2). Mandibular scrobe unisetose 4

3'. Mandibular scrobe plurisetose . . . . Brachinina _sensu stricto_

4(3). Mentum with a tooth on anterior edge (absent in _Styphlodromus_); upper spur on anterior tibia internal (fig. 36); vestiture of male anterior tarsal articles arranged diagonally on asymmetric articles . . . . Aptinina, new subtribe

4'. Mentum without a tooth; upper spur external or almost so (fig. 35); vestiture of male anterior tarsal articles not diagonal, articles symmetric . . . . Pheropsophina, new subtribe

4.2 Tribe Crepidogastrini Jeannel

Crepidogastritae Jeannel, 1949:1080.

Crepidogastrini Basilewsky, 1959:233.

Type genus.—_Crepidogaster_ Boheman, 1848:68.

The following combination of characteristics is diagnostic of this tribe: labrum with eight setae; mandibular scrobe plurisetose; palpi with terminal articles swollen or securiform; gular sutures convergent behind; anterior coxal cavities biperforate, closed behind; propleural suture present; upper spur of anterior tibia internal; ventral vestiture of male anterior tarsal articles spongy and pad-like; middle coxal cavities conjunct-confluent; mesepimera absent or almost so; apical elytral membrane absent; hind coxal cavities confluent; metasternum and metepisterna greatly reduced; wings absent; male parameres not balteate; valvifers of female ovipositor setiferous

anteriorly; coxite and stylus of female ovipositor fused.

This tribe contains the genera *Crepidogaster*, *Tyronia*, *Crepidogastrinus*, *Crepidonellus*, *Crepidogastrillus*, *Brachynillus*, and *Crepidolomus*.

4.21 Key to the Genera of the Tribe Crepidogastrini

(Translated and modified from Basilewsky, 1959)

1. Lateral edge of pronotum with many spine-like setae; lateral edge of elytron also with spine-like setae. . . . . *Crepidogastrinus* Basilewsky

1'. Lateral edge of pronotum with one or two pairs of setae; depression 8 of elytron with umbilicate setae only. 2

2(1'). Elytra short and wide, maximum width greater than length at suture. 3

2'. Elytra long and narrow, maximum width shorter than length at suture. 4

3(2). Pronotum with one pair of lateral setae, near the middle; terminal article of labial palpus securiform. . . . . *Crepidonellus* Basilewsky

3'. Pronotum with two pairs of lateral setae, one just before hind angles and one near the middle; last article of labial palpus globose . . . . *Crepidogastrillus* Basilewsky

4(2). Pronotum with one pair of lateral setae, near the middle. . . 5

4'. Pronotum with two pairs of lateral setae, one just before hind angles and one near the middle. 6

5(4). Terminal article of labial palpus strongly swollen or securiform; terminal article of maxillary palpus very swollen

or securiform . . . . Crepidogaster Boheman

5'. Terminal article of labial palpus fusiform or subcylindrical; terminal article of the maxillary palpus globose, but not securiform; body slender and elongate . . . Brachynillus Reitter

6(4'). Terminal article of labial palpus strongly swollen or securiform; terminal article of maxillary palpus very swollen or securiform . . . . Tyronia Liebke

6'. Terminal article of labial palpus fusiform or sybcylindrical; terminal article of the maxillary palpus globose, but not securiform; body slender and elongate . . . . Crepidolomus Basilewsky

4.22 Genus Crepidogaster Boheman

(Figs. 7, 11, 38, 50, 52, 63, 64)

Crepidogaster Boheman 1848:68. Type species.—Crepidogaster bimaculatus Boheman 1848:68. (Subsequent designation, Jeannel, 1949:1081).

Crepidostoma Motschulsky 1862:54. Type species.—Crepidogaster rufescens Motschulsky 1862:54. (By monotypy).

Diagnostic combination.—Terminal article of labial palpus strongly swollen or securiform; terminal article of maxillary palpus very swollen or securiform; pronotum with one pair of setae, near the middle; elytra long and narrow, their combined maximum width shorter than their length along the suture.

Description.—Small to large-sized beetles, 4.0 to 16.0 mm (from Basilewsky, 1959).

Color. Generally ferrugineous with brown or black elytra which are sometimes spotted.

Microsculpture. Isodiametric on head, pronotum, and elytra.

Macrosculpture. Entire dorsal surface covered by small setiferous punctulae.

Head. Labrum entire, with eight evenly spaced setae transversely arrayed on disc. Clypeus rectangular, with two large setae, one inside each anterior angle. Front punctate with numerous setae scattered throughout; furrows shallow; one supraorbital seta over each eye; bead over eye ending midway the length of eye. Eyes protruding, but not prominent. Antennae short, robust, pubescent throughout. Mandibles (fig. 7) each broad, triangular, curved at tip; cutting edge with one small retinacular tooth; ventral groove with short golden setae; scrobe plurisetose, but with one larger seta. Labial palpi (fig. 11) each with last article securiform; all articles with numerous small setae. Maxillary palpi each more or less filiform, last article swollen; all articles with numerous small setae. Ligula (fig. 11) membranous and square with anterior angles produced, and center ventrally produced into a plurisetose sclerotized convexity. Mentum (fig. 11) well developed without tooth. Gula (fig. 11) narrowed behind.

Prothorax. As described for the Tribe Crepidogastrini, plus numerous punctulae on disc. Anterior tibiae (fig. 38) each with upper spur internal, at middle of comb emargination. Male anterior tarsal articles (fig. 50) symmetrical, vestiture beneath first and second consisting of apically widened setae forming pads. Female anterior tarsal articles without vestiture.

Pterothorax. Mesepimera absent, or almost so. Metathoracic process acute. Metepimeron lobe rounded apically. Elytral humeri sloping, lateral bead discontinuous before base of humerus. Depression

setae present between well developed carinae or costae. Epipleura pubescent, wide anteriorly and medially, but narrowed toward apex. Wings absent.

Abdomen. As described for the Tribe, plus a pair of ambulatory setae arising laterad, at apex of sterna 3-6.

Genitalia. Male (figs. 63, 64) with small parameres, not balteate, asymmetrical. Median lobe various, ligule absent. Endophallus of medium length, with two apical microtrichiate fields and one basal field; virga absent. Female (fig. 52) with elongate, narrow, spatulate, and unarmed styli; coxites small, continuous with stylus; valvifers setose anteriorly; bursa unarmed.

Etymology.—Latin, crepo = rattle; Greek, gaster = stomach; referring to the beetles' ability to crepitate.

Distribution.—The species of Crepidogaster occur south of the equator in Africa and Madagascar, with only two populations of one species known north of the equator in east Africa.

4.23 Genus Tyronia Liebke

Tyronia Liebke, 1934:18. Type species—Crepidogaster numeratus Chaudoir, 1876:96. (Original designation).

Diagnostic combination.—As given in the key.

Description.—Small-sized beetles, 3.5 to 7.0 mm (from Basilewsky, 1959). For details see Basilewsky (1959).

Distribution.--The species of Tyronia occur in south and middle Africa on the eastern side of the continent. Two species occur in the Oriental Region, one in India, and one in Ceylon.

4.24 Genus *Brachynillus* Reitter

Brachynillus Reitter, 1904:178. *Type species*.—*Brachynillus varendorffi* Reitter 1904:178. (By monotypy).

Diagnostic combination.—As given in the key.

Description.—Small-sized beetles, 5.0 to 5.5 mm (from Basilewsky, 1959). For details see Basilewsky (1959).

Distribution.—The type species is found as a troglobite in the "Grottes de Kulumuzi" in Tanganyika. A second species placed in the genus by Basilewsky is known from one specimen labeled "Cape Town."

4.25 Genus *Crepidolomus* Basilewsky

Crepidolomus Basilewsky, 1959:331. *Type species*.—*Brachynillus extimus* Jeannel, 1955:62. (Original designation).

Diagnostic combination.—As given in the key.

Description.—Small-sized beetles, 5.5 mm (from Basilewsky, 1959). For details see Basilewsky (1959).

Distribution.—One female specimen is known from Andohahelo, on the southern tip of Madagascar.

4.26 Genus *Crepidonellus* Basilewsky

Crepidonellus Basilewsky, 1959:334. *Type species*.—*Crepidogaster pusillus* Peringuey, 1888:76. (Original designation).

Diagnostic combination.—As given in the key.

Description.—Very small-sized beetles, 3.6 to 4.3 mm (from Basilewsky, 1959). For details see Basilewsky (1959).

Distribution.—The members of *Crepidonellus* are found in South

West Africa and Cape Province.

4.27 Genus Crepidogastrillus Basilewsky

Crepidogastrillus Basilewsky, 1959:337. Type species.—Crepidogastrillus curtulus Basilewsky, 1959:338. (Original designation).

Diagnostic combination.—As given in the key.

Description.—Very small-sized beetles, 3.4 to 3.6 mm (from Basilewsky, 1959). For details see Basilewsky (1959).

Distribution.—The range of this genus extends from Cape Province north into South West Africa, and east to North West Rhodesia.

4.28 Genus Crepidogastrinus Basilewsky

Crepidogastrinus Basilewsky, 1957:117. Type species.—Crepidogastrinus kochi Basilewsky, 1957:118. (By original designation and monotypy).

Diagnostic combination.—As given in the key.

Description.—Very small-sized beetles, 3.0 mm (from Basilewsky, 1959). For details see Basilewsky (1957, 1959).

Distribution.—The range of this species is confined to southern Angola and South West Africa.

4.3 Tribe Brachinini Bonelli

Brachinii Bonelli, 1809: tab. syn.

Brachynidae Stephen, 1827:5.

Brachynini Erichson, 1837:25. (Brachinini, of authors).

Brachinida Heer, 1838:4.

Brachinides Lacordaire, 1854:97.

Brachinites Jacquelin du Val, 1857:55.

Brachinina Thomson, 1859:6. (Brachynina, of authors).

Brachyninae Kolbe, 1898:60.

Brachynitae Alluaud, 1916:50.

Brachinidae Jeannel, 1942:1102.

The following combination of characteristics is diagnostic of this tribe: mandibular scrobe plurisetose or unisetose; labial palpus with terminal article wedge-shaped, subcylindrical, or globose-attenuate; gular sutures divergent behind; anterior coxal cavities uniperforate or biperforate; propleural suture present or absent; upper spur of anterior tibia present or absent, internal or external; ventral vestiture of male anterior tarsal articles composed of two parallel rows of modified setae; mesepimeron present, wide, but not reaching middle coxa; male parameres balteate.

This tribe contains the subtribes Mastacina new subtribe, Pheropsophina Jeannel, Aptinina new subtribe, and Brachinina Bonelli.

4.31 Subtribe Mastacina new subtribe

Type genus.—Mastax Fischer von Waldheim, here designated.

This subtribe contains a single genus. The diagnostic characteristics are given below.

4.311 Genus Mastax Fischer von Waldheim
(Figs. 6, 10, 28, 40, 49, 53, 54, 62)

Mastax Fischer von Waldheim, 1825-28:111. Type species.—Brachinus thermarum Stevens, 1806:166. (Subsequent designation by Jedlička, 1963:547).

Brachinus (of authors).

Diagnostic combination.—Mandibular scrobes reduced, unisetose; last article of palpi fusiform with subulate tip; mentum with single tooth and deep pit (fig. 10); mandibles each with large bifid terebral tooth; anterior coxal cavities biperforate-separate, closed behind; propleural sutures present; pronotum with two longitudinal ridges on disc; upper spur of anterior tibia absent; middle coxae conjunct-separate; metasternal process (between middle coxae) broadly rounded; hind coxae widely separated; wing (fig. 28); parameres of male genitalia extremely small, adherent to base of median lobe; ligule absent; coxite of female genitalia unisetose, stylus short.

Description.—Small-sized beetles, 2.5 to 4.0 mm.

Color. Head, prothorax, and legs generally ferrugineous to brown. Abdomen, antennae, and "knees" infuscated. Elytra brown with white spots.

Microsculpture. Isodiametric on head and pronotum, except where obliterated by macrosculpture. Longitudinally-stretched meshes on elytra.

Macrosculpture. Longitudinal wrinkles on head and pronotum. Minute chevron-shaped wrinkles on costae of elytra, surface "satin-like" in appearance.

Head. Labrum emarginate, with eight evenly spaced setae transversely arranged on disc. Clypeus rectangular, with six evenly spaced setae transversely arranged on disc. Front longitudinally wrinkled with numerous scattered setae; furrows shallow, reflexed strongly at sides over antennal bases; one supraorbital seta over each eye, one psuedosupraorbital seta behind each eye; bead over eye

carinate and prolonged on side of vertex behind psuedosupraorbital seta; shallowly depressed at middle. Eyes prominent. Antennae robust; articles 5-10 as wide as long, moniliform; article 11 fusiform and subulate at apex; all articles pubescent. Mandibles (fig. 6) arcuate each with a strong bifid terebral tooth; basal margin with dense brush of fine golden setae, also a row of fine setae in ventral groove; scrobes effaced, but unisetose. Palpi (fig. 10) each with terminal article fusiform, tip subulate; all articles pubescent. Ligula bilobed; lobes thin and densely setiferous; median portion slightly swollen with two large setae. Mentum (fig. 10) short, with single tooth medially on anterior edge; center of mentum excavated and surrounded by setae. Gula (fig. 10) widened behind.

Prothorax. As described for the Subtribe Masticina, and disc with two longitudinal carinae on each side of midline. Anterior tibia (fig. 40) without upper spur. Male and female with first two tarsal articles expanded, the male (fig. 49) with modified vestiture beneath these two articles. Male with a curved nonarticulated spine (fig. 40) on right side of glabrous antennal comb-trough.

Pterothorax. Metathoracic process (between middle coxae) broadly rounded, middle coxae widely separated. Hind coxae widely separated. Metepimeron lobe small, but rounded caudally. Elytra quadrate, humeri prominent, lateral bead prolonged inside humerus to base of fifth stria. Setae present between weakly raised costae in striae 2, 4, 6, 8. Epipleura wide throughout; pubescent. Wings as in fig. 28.

Abdomen. As described for the Division Brachinida, except with one pair of ambulatory setae at apex of sterna 2-5.

Genitalia. Male (fig. 53, 54) with extremely small parameres

adherent to base. Median lobe various, but usually slightly arcuate and blunt at apex. Endophallus extremely complicated with (in repose) two sclerites apically and one sclerite basally; membrane reinforced with a thin, spiraled, sclerotized rod. Female (fig. 62) with short, narrow, arcuate and unarmed styli; valvifer transverse, narrow, and elongate; coxite unisetose; bursa unarmed; spermatheca present, "sausage-shaped."

Etymology.—Greek, mastokos = jaw, mouth; referring to the huge retinacular tooth on the mandibles of these beetles.

Distribution.—(Fig. 457). Species of Mastax occur on both sides of the equator, but are not confined to the tropics. Species are known from south of the equator in South Africa and southern Sumatra. North of the equator some species occur in western, northern, and eastern Africa, the Congo, Saudia Arabia, Iraq, (on both sides of the Caspian Sea), Western India, Ceylon, Southeast Asia, Hainan, and Formosa.

4.32 Subtribe Pheropsophina Jeannel

Pheropsophini Jeannel, 1948:1084.

Type genus.—Pheropsophus Solier, 1833:46.

The following combination of characteristics is diagnostic for this subtribe; mandibular scrobe unisetose; terminal palpal article wedge-shaped; anterior coxal cavities open or closed behind; propleural suture present or absent; upper spur of anterior tibia slightly internal; male anterior tarsal articles symmetrical or almost so; middle coxal cavities separate-conjunct; apical elytral membrane absent; at least some depressions of elytra microrugose; hind coxae contiguous—separate; lobe of metepimeron large; parameres of male

genitalia small, balteate; dorsal surface of median lobe at basal bend notched; valvifer of female ovipositor glabrous.

This subtribe includes the genera Pheropsophus Solier and Pheropsophidius Hubenthal.

4.321 Key to the Genera and Subgenera of the Subtribe Pheropsophina

1. Elytra costate, with costae low and rounded, evenly confluent with depressions; propleural suture absent. . . . . Pheropsophidius 2

1'. Elytra carinate, carinae sharp or rounded, well defined and abruptly confluent with depressions; propleural sutures present . . . . Pheropsophus 3

2(1). Anterior coxal cavities narrowly opened behind; depressions on disc of elytra without macrosculpture (except near scutellum); apex of elytra obliquely truncate, sutural length shorter than lateral length . . . . subgenus Protopheropsophus Hubenthal

2'. Anterior coxal cavities closed behind; depressions on disc with macrosculpture in depressions; apex of elytron almost truncate; costae well defined . . . . subgenus Pheropsophidius Hubenthal

3(1'). Apical border of elytron with numerous long setae . . . . subgenus Pheropsophus Solier

3'. Apical border of elytron without long setae, with or without very small ones (barely visible at 50X) 4

4(3'). Carinae of elytra broader than the depressions, and rounded dorsally . . . . Stenaptinus Maindron

4'. Carinae of elytra very narrow, sharp dorsally (Madagascar). . . . . *Aptinomorphus* Jeannel

4.322 Genus *Pheropsophus* Solier
(Figs. 5, 14, 25, 30, 34, 44, 51, 61, 69, 70)

Pheropsophus Solier, 1833:463. *Type species*.—*Brachinus senegalensis* Dejean, 1825:308. (Subsequent designation, by Jeannel, 1949: 1084).

Stenaptinus Maindron, 1906:15. *Type species*.—*Stenaptinus krichna* Maindron, 1906:15. (Subsequent designation, by Jeannel, 1949: 1084).

Parapheropsophus Hubenthal, 1914:442. *Type species*.—*Brachinus verticalis* Dejean, 1825:302. (Subsequent designation, by Jeannel, 1949:1084; Darlington, 1968:234).

Aptinomorphus Jeannel, 1949:1091. *Type species*.—*Pheropsophus acutecostatus* Fairmaire, 1892:168. (Original designation).

Brachinus (of authors).

Diagnostic combination.—Elytral costae carinate, carinae sharp or rounded, well defined and more strongly contrasting from depressions; propleural sutures present.

This genus includes the subgenera *Pheropsophus* Solier, *Stenaptinus* Maindron, and *Aptinomorphus* Jeannel.

4.3221 Subgenus *Pheropsophus* Solier
(Figs. 5, 14, 25, 30, 34, 44, 61, 69, 70)

Parapheropsophus Hubenthal, 1914:442. Darlington, 1968:234.

Diagnostic combination.—As given for genus *Pheropsophus*, plus

apical border of elytra with fringe of long closely spaced setae.

Description.—Medium to large-sized beetles, 15.0 to 25.0 mm.

Color. Generally yellow or ferrugineous, with black markings.

Microsculpture. Isodiametric on head, but slightly stretched transversly on pronotum and elytral carinae.

Macrosculpture. Depressions between elytral carinae with numerous longitudinal microrugosities.

Head. Labrum entire, with six evenly spaced setae transversely arranged near anterior margin. Clypeus rectangular, with two setae on each side near middle. Front smooth, glabrous; furrows very shallows; one supraorbital seta over each eye; bead over eye almost absent; eyes prominent. Antennae long, robust, first two articles setiferous 3-11 pubescent. Mandibles (fig. 5) each broad, arcuate; cutting edge with two small terebral teeth and two retinacular teeth; ventral groove with short golden setae; basal margin with pensillus; scrobe unisetose. Labial palpi (fig. 14) each with terminal article narrowly wedge-shaped; terminal and penultimate articles with numerous stiff setae. Maxillary palpi each more or less filiform, terminal three articles with numerous stiff setae. Ligula (fig. 14) membranous and square, with anterior angles barely produced; center ventrally produced into a bisetose sclerotized carina. Mentum (fig. 14) well developed, without a tooth. Gula (fig. 14) widened behind.

Prothorax. As described under Subtribe Pheropsophina. Anterior tibiae each with subterminal spur in intermediate position at top of comb emargination. Male anterior tarsal articles 1-3 slightly asymmetrical, vestiture beneath consisting of two parallel rows of spatulate setae. Female anterior tarsal articles symmetrical,

vestiture absent. Anterior coxal cavities barely closed behind.

Pterothorax. Anterior metathoracic process acute. Middle coxal cavities contiguous-separate. Metepimeron lobe large, rounded apically. Elytral humeri square, lateral bead entire to base of humerus. Strial setae present between well developed carinae. Epipleura wide anteriorly and medially, but narrowing toward apex; not pubescent. Wings present (fig. 30).

Abdomen. As described under Division Brachinida, except one pair of ambulatory setae at apices of sterna 3-6.

Genitalia. Male (fig. 69, 70) with small balteate, asymmetrical parameres; median lobe variable, but symmetrical, and notched near base; ligule double, narrow, and spatulate; endophallus short with various fields of microtrichia; virga absent. Female (fig. 61) with elongate, narrow, slightly curved styli, usually armed with small spines; coxites small, robust; valvifers glabrous; bursa unarmed, except an elongate sclerite at entrance of bursa.

Etymology.—Greek, phero = bearer; psophos = sound, or noise; hence "noise bearer" referring to the crepitating behavior of these beetles.

Distribution.—The range of this subgenus extends over much of Africa and Madagascar, with the exception of the desert region in the north of Africa, and eastward across Asia Minor, India, and eastern Asia, into the Malay Archipelago, New Guinea, New Britain, New Ireland, the Solomons, and Australia.

4.3222 Subgenus Stenaptinus Maindron

(Fig. 51)

Diagnostic combination.—As in subgenus Pheropsophus, except wings absent, anterior coxal cavities slightly open behind; female styli shorter, more spatulate, unarmed.

Description.—Medium to large-sized beetles, about 10.0 to 15.0 mm.

Color. Ferrugineous venter and legs, black above, sometimes head and pronotum also ferrugineous.

Microsculpture. As in subgenus Pheropsophus.

Macrosculpture. As in subgenus Pheropsophus.

Head. As in subgenus Pheropsophus.

Prothorax. As in subgenus Pheropsophus, except coxal cavity slightly open behind.

Pterothorax. As in subgenus Pheropsophus, except metasternum very short, shorter than longitudinal diameter of middle coxa (fig. 26); metepisterna almost square; elytral humeri absent; wings absent.

Abdomen. As in subgenus Pheropsophus.

Genitalia. Male as in subgenus Pheropsophus. Female (fig. 51) styli unarmed, wider, and shorter than subgenus Pheropsophus, otherwise similar.

Etymology.—Greek, stenos = narrow; Aptinus = name of another brachinine genus; referring to the very narrow humeri of these beetles.

Distribution.—The range of this subgenus is the Old World Tropics, including tropical Africa, India, Ceylon, southeastern Asia, Celebes, Taiwan, Philippines, and possibly New Guinea.

4.3223 Subgenus Aptinomorphus Jeannel

Diagnostic combination.—As in subgenus Pheropsophus, except for the following characters: wings absent; elytral carinae very narrow, ridge-like; apex of elytra without setae; female styli very short and broad.

Description.—Medium to large-sized beetles, 12.0 to 30.0 mm.

Color. Ferrugineous venter and legs; head and pronotum ferrugineous or brown; elytra black or brown.

Microsculpture. As in subgenus Pheropsophus.

Macrosculpture. As in subgenus Pheropsophus.

Head. As in subgenus Pheropsophus.

Prothorax. As in subgenus Pheropsophus.

Pterothorax. As in subgenus Stenaptinus.

Abdomen. As in subgenus Pheropsophus.

Genitalia. Male as in subgenus Pheropsophus. Female styli very short and broad, unarmed, otherwise as in subgenus Pheropsophus.

Etymology.—Aptinus = another brachinine genus; Greek, morphe = form or shape; referring to the narrow, wingless condition of these beetles, reminding one of members of Aptinus.

Distribution.—The species of this subgenus are confined to Madagascar.

4.323 Genus Pheropsophidius Hubenthal

(Figs. 4, 12, 35, 59, 423, 427, 437-442, 444, 445_1, 445_2)

Pheropsophidius Hubenthal, 1911:547. Type species.—Cicindela aequinoctialis Linné, 1763:395. (Subsequent designation, by

Jeannel, 1949:1084).

Protopheropsophus Hubenthal, 1911:548. Type species—Pheropsophus biplagiatus Chaudoir, 1876:18. (By monotypy).

Brachinus (of authors).

Diagnostic combination.—Elytra costate, costae low and rounded, evenly flared into depressions; propleural suture absent.

This genus includes the subgenera Pheropsophidius Hubenthal and Protopheropsophus Hubenthal.

4.3231 Subgenus Pheropsophidius Hubenthal

(Figs. 4, 12, 35, 59, 423, 440, 441, 442, 445)

Diagnostic combination.—As in subgenus Pheropsophus, except costae of elytra not carinate, lower, rounded, and evenly confluent with depressions; propleural sutures absent; female styli short and broad.

Description.—Medium to large-sized beetles, about 12.0 to 20.0 mm.

Color. Yellow or ferrugineous with black markings.

Microsculpture. As in subgenus Pheropsophus.

Macrosculpture. As in subgenus Pheropsophus, except discal depressions with fewer microrugosities.

Head. As in subgenus Pheropsophus.

Prothorax. As in subgenus Pheropsophus, except propleural sutures absent.

Pterothorax. As in subgenus Pheropsophus, except elytral costae as described above.

Abdomen. As in subgenus Pheropsophus.

Genitalia. Male (figs. 440, 441, 442) as in subgenus Pheropsophsus. Female (fig. 59) styli short and broad, otherwise as in subgenus Pheropsophus.

Etymology.—Greek, phero = bearer; psophos = sound; idion = little; referring to the smaller, but Pheropsophus-like members of this genus.

Distribution.—The range of this subgenus extends from southern Mexico to South America, as far south as 40° S in Argentina.

4.3232 Subgenus Protopheropsophus Hubenthal

(Figs. 427, 437, 438, 439, 444, 445)

Diagnostic combination.—As in subgenus Pheropsophidius, except elytra scarcely costate on disc; anterior coxal cavities open behind; wings absent; humeri absent; apex of elytra obliquely truncate; microrugosities of elytral depressions absent from disc.

Description.—Small to large-sized beetles, 11.0 to 14.0 mm.

Color. Head, prothorax, venter around coxae, and legs ferrugineous. Elytra and epipleura dull black, each with a large orange spot.

Microsculpture. As in subgenus Pheropsophus.

Macrosculpture. As in subgenus Pheropsophus, except microrugosities absent from disc.

Head. As in subgenus Pheropsophus.

Prothorax. As in subgenus Pheropsophidius, except anterior coxal cavities open behind.

Pterothorax. As in subgenus Stenaptinus, except elytra as described above.

Abdomen. As in subgenus *Pheropsophus*.

Genitalia. Male (figs. 437, 438, 439) as in subgenus *Pheropsophus*. Female styli (fig. 444) short and broad, otherwise as in subgenus *Pheropsophus*.

Etymology.—Greek, *proto* = first; *Pheropsophus* another genus of brachinines; referring to Hubenthal's idea that this is the most primitive group of Pheropsophina.

Distribution.—(Fig. 445). The members of this monotypic subgenus are known only from the southern slopes of the Sierra Madre del Sur in Oaxaca, Mexico.

4.33 Subtribe Aptinina new subtribe

Type genus.—*Aptinus* Bonelli, here designated.

The following combination of characteristics is diagnostic of this subtribe: mandibular scrobe unisetose; mentum with tooth on anterior edge; anterior coxal cavities uniperforate; propleural suture absent; antennal comb spur internal; male anterior tarsi with articles 1-3 asymmetrical (figs. 43, 47); vestiture of male anterior tarsal articles diagonally arranged; middle coxal cavities confluent; apical elytral membrane absent; metacoxal cavities confluent; coxites of female ovipositor setiferous apically.

This subtribe includes the genera *Aptinus* Bonelli, *Styphlomerus* Chaudoir, *Styphlomerinus* Jeannel, and *Styphlodromus* Basilewsky.

4.331 Key to the Genera of the Subtribe Aptinina

1. Integument black; dorsal pubescence sparse; wingless; humeri absent. . . . . *Aptinus* Bonelli

1'. Integument ferrugineous or yellow, elytra with black areas; dorsal pubescence dense; winged; humeri square and prominent. 2

2(1'). Mentum with large tooth on anterior edge 3

2'. Mentum without large tooth on anterior edge. . . . . .Styphlodromus Basilewsky

3(2). Dorsal surface with large punctures forming a very rugose surface; elytra concolorous. . . . . . .Styphlomerinus Jeannel

3'. Dorsal surface finely and densely punctate; elytra bicolored. . . . . Styphlomerus Chaudoir

4.332 Genus Aptinus Bonelli
(Figs. 3, 17, 36, 43, 55, 56, 57, 58)

Aptinus Bonelli, 1810: tab. syn. Type species.—Brachinus bombarda Illiger, 1800:112. (Subsequent designation, by Jeannel, 1942: 1116).

Aptinidius Jeannel, 1942:1116. Type species.—Aptinus displosor Dufour, 1811:70. (Original designation). NEW SYNONYMY.

Diagnostic combination.—Integument black (red prothorax in members of Aptinus displosor Dufour); dorsal pubescence sparse; humeri absent; wings absent; male genitalia variously contorted, endophallus with sclerite "complex"; female coxites plurisetose, setae unmodified, bursa with sclerite "complex."

Description.—Medium-sized beetles, 8.0 to 14.0 mm.

Color. Generally black, some species with rufous appendages and prothorax.

Microsculpture. Isodiametric on head, pronotum, and elytra,

slightly transversely stretched on pronotum.

Macrosculpture. Pronotum usually with deep setiferous punctures.

Head. Labrum entire to slightly lobate, with six or eight evenly spaced setae transversely arranged near anterior margin. Clypeus rectangular, with numerous setiferous punctures scattered on disc. Front smooth, but with numerous setae; furrows very shallow, with deep groove separating them from antennal base cover and eye; one supraorbital seta over each eye; bead over eye ending at hind margin of eye. Eyes prominent. Antennae long, narrow, pubescent throughout. Mandibles (fig. 3) each broad, triangular, curved at tip; cutting edge with one small terebral tooth and three retinacular teeth; ventral groove with short golden setae; scrobe unisetose. Labial palpi (fig. 17) each with last article narrowly wedge-shaped; terminal and penultimate article bearing numerous stiff setae. Maxillary palpi more or less filiform; last three articles with numerous stiff setae. Ligula (fig. 17) membranous with anterior angles produced, and center ventrally produced into a plurisetose sclerotized convexity. Mentum (fig. 17) well developed with a single entire or emarginate tooth at anterior edge. Gula (fig. 17) widened behind.

Prothorax. As described under Subtribe Aptinina, except that numerous, large, deep, setiferous, punctures occur on disc. Anterior tibiae (fig. 36) each with subterminal spur internal, at middle of comb emargination. Male anterior tarsal articles (fig. 43) 1-3 asymmetrical, with ventral vestiture consisting of two parallel rows of spatulate setae, diagonally arranged beneath each article. Female anterior tarsal articles symmetrical, vestiture absent.

Pterothorax. Anterior metathoracic process acute, mesocoxae

contiguous-confluent. Hind coxae contiguous. Metepimeron lobe very large, rounded apically. Elytral humeri strongly sloping, lateral bead entire to base of humerus. Depression setae present between well developed costae. Epipleura wide medially and anteriorly, but narrowing toward apex; entirely pubescent. Wings absent.

Abdomen. As described under Division Brachinida, except one pair of ambulatory setae at apices of sternites 2-5.

Genitalia. Male (figs. 56, 57) with small balteate, asymmetrical parameres; median lobe variable, but highly asymmetrical and contorted; ligule single, large, and spatulate; endophallus short, with two ventral microtuberculate plates and an apical sclerite. Female (fig. 58) with very short, broad, arcuate, and unarmed styli; valvifers robust and plurisetose; bursa with complicated arrangement of sclerites (fig. 55).

Etymology.—Greek, apten = unable to fly; referring to the winglessness of all known species of this genus.

Distribution.—The species of Aptinus occur in the southern parts of Europe from Spain to the Black Sea, mostly in the mountainous regions of the Alps and Pyrenees.

4.333 Genus Styphlomerus Chaudoir

(Figs. 2, 16, 27, 39, 47, 48, 67, 68)

Styphlomerus Chaudoir, 1875: in rapport sur un memoire de M. le Baron de Chaudoir, by M. Putzeys. Type species.—Brachinus aulicus Dejean, 1831:422. (Subsequent designation, by Alluaud 1911:129). Andrewes (1939:138) designated Brachinus quadrimaculatus Dejean, and Habu (1967:295) cites the later designation.

Styphromerus Chaudoir, 1876:88. Lapsus calami.

Diagnostic combination.—Mandibular scrobe unisetose; labial palpus with terminal article cylindrical; mentum with a large median tooth; mandibles simple, each with one terebral tooth and one terebral ridge; propleural suture absent; anterior tibiae each with subterminal spur internal at middle of comb emargination; male anterior tarsal articles asymmetrical; middle coxae contiguous-confluent; elytra not costate; elytral epipleura wide or narrow; apical membrane of elytra absent; hind coxae confluent; metasternal process (between middle coxae) acute; wings present; parameres of male genitalia small, balteate; ligule double; valvifers of female genitalia plurisetose; styli short, narrow, and arcuate.

Description.—Medium-sized beetles, 4.5 to 12.0 mm.

Color. Generally testaceous to yellow, many species with blackish elytra with testaceous or yellow spots.

Microsculpture. Isodiametric on head, pronotum, and elytra.

Macrosculpture. Dorsal surface of head, pronotum, and elytra densely microrugose and punctate.

Head. Labrum entire, with six evenly spaced setae transversely arranged on disc. Clypeus rectangular with a single seta at each anterior corner and several small setae scattered over disc. Front microrugose, with numerous setiferous punctures; furrows very shallow; one supraorbital seta over each eye; bead over eye incomplete. Eyes prominent. Antennae long, robust, pubescent throughout. Mandible (fig. 2) broad, triangular, curved at tip; terebral margin with an elongate terebral ridge, and two retinacular teeth; ventral groove with short golden setae; scrobe unisetiferous. Labial palpi (fig. 16) each

with terminal article slightly wedge-shaped; terminal and penultimate articles plurisetose, penultimate also bearing two large setae. Maxillary palpi each more or less filiform; last three articles plurisetose. Ligula (fig. 16) membranous and square with anterior angles produced, center ventrally produced into plurisetose sclerotized convexity. Mentum (fig. 16) well developed, with a single tooth at anterior edge. Gula (fig. 16) widened behind.

Prothorax. As described under Subtribe Aptinina, except disc with microrugosities and scattered punctures. Anterior tibiae (fig. 39) with subapical spur internal at middle of comb emargination. Male anterior tarsal articles (fig. 47) 1-3 asymmetrical, vestiture beneath consisting of two parallel rows of spatulate setae. Female anterior tarsal articles symmetrical, vestiture absent.

Pterothorax. Anterior metathoracic process (between middle coxae) acute, prolonged, middle coxae contiguous-confluent. Hind coxae confluent. Metepimeron lobe small, parallel-sided. Elytral humeri square, lateral bead entire to base of humerus. Depression setae present, erect. Epipleura pubescent; wide medially and anteriorly, but either narrowing toward apex or wide throughout. Wings present (fig. 27).

Abdomen. As described under Division Brachinida, except one or more pairs of ambulatory setae at apices of sterna 2-5.

Genitalia. Male (figs. 67, 68) with small, balteate, asymmetrical parameres; median lobe various, but usually elongate, narrow, curved; apical sclerotization poorly defined, but present; ligule double; endophallus short with numerous microtrichia scattered over surface. Females with short, narrow, and arcuate, unarmed styli; coxites

trapezoidal, thin; valvifers plurisetose; bursa without sclerites.

Etymology.—Greek, styphlos = rough; meros = thigh; referring to the punctate femora of these beetles.

Distribution.—The range of this genus extends on both sides of the equator in southern and middle Africa.

4.334 Genus Styphlomerinus Jeannel

Styphlomerinus Jeannel, 1949:1118. Type species—Styphlomerus fuscifrons Fairmaire 1897:367. (Original designation).

Diagnostic combination.—As in Styphlomerus, except dorsum more strongly macropunctate; elytra without spots (in known species); ligule single.

Description.—Small to medium-sized beetles, about 5.0 to 8.5 mm (Jeannel, 1949).

Color. Head, prothorax, venter, and legs ferrugineous; sometimes head and various sclerites infuscated. Elytra and epipleura dark grey or black.

Microsculpture. As in genus Styphlomerus.

Macrosculpture. Dorsal surface coarsely punctate and rugose.

Head. As in genus Styphlomerus.

Prothorax. As in genus Styphlomerus.

Pterothorax. As in genus Styphlomerus, except epipleura not wide throughout its length.

Abdomen. As in genus Styphlomerus.

Genitalia. Male as in genus Styphlomerus, except ligule single. Female as in genus Styphlomerus.

Etymology.—Greek, styphlos = rough, meros = thigh, inus =

having the nature of; referring to the similarity between members of this genus and *Styphlomerus*.

Distribution.—The range of this genus extends from India to Japan, and south in the Malayan Archipelago to Java, and on the islands of Madagascar, Hainan, and Taiwan. According to Jeannel (1949), no species inhabit continental Africa.

4.335 Genus *Styphlodromus* Basilewsky

Styphlodromus Basilewsky, 1959a:240. *Type species*.—*Styphlodromus bicolor* Basilewsky, 1959a:241. (Original designation).

Diagnostic combination.—As in *Styphlomerus*, except mentum without tooth; dorsal surface macropunctate; ligule doubled or not (nature of doubling different than in *Styphlomerus*); elytra with stripes or spots.

Description.—Small to medium-sized beetles, 4.5 to 7.0 mm.

Color. Head, prothorax, venter, and legs ferrugineous. Elytra and epipleura dark gray to black, variously spotted or striped.

Microsculpture. As in genus *Styphlomerus*.

Macrosculpture. As in genus *Styphlomerinus*.

Head. As in genus *Styphlomerus*.

Prothorax. As in genus *Styphlomerus*.

Pterothorax. As in genus *Styphlomerus*, except epipleuron not wide throughout its length.

Abdomen. As in genus *Styphlomerus*.

Genitalia. Male as in genus *Styphlomerus*, except ligule single or double, and endophallus folding pattern more complex. Female as in genus *Styphlomerus*.

Etymology.—Greek, *styphlos* = rough; *dromeus* = runner; referring

to the rapidity with which these Styphlomerus-like beetles run.

Distribution.—The range of this genus extends from middle to southern Africa.

Remarks.—Although this genus is presently monotypic in the literature, I have seen specimens representing four more species. I have not described and named these, because it is possible they already have names and have been placed wrongly in the genus Styphlomerus or even Brachinus.

4.34 Subtribe Brachinina Bonelli

Type genus.—Brachinus Weber.

The following combination of characteristics is diagnostic of this subtribe: mandibular scrobes plurisetose; mentum without a tooth on anterior edge; anterior coxal cavities uniperforate, closed behind; propleural suture absent; anterior tibiae each with subterminal spur external or only slightly internal at top of comb emargination; male anterior tarsal articles either symmetrical or asymmetrical; vestiture beneath articles 1-3 longitudinally or diagonally arranged; middle coxal cavities confluent; apical elytral membrane present; hind coxal cavities confluent; coxites of female ovipositor glabrous apically.

This subtribe includes the genera Brachinus Weber, Aptinoderus Hubenthal, and Brachinulus Basilewsky.

4.341 Key to the Genera of the Subtribe Brachinina

1. Apical membrane of elytron fully developed, wider than sutural flange near apex. . . . . Brachinus Weber

1'. Apical membrane of elytron narrow, narrower than sutural flange

near apex. 2

2(1'). Integument black, apical articles of labial and maxillary palpi cylindrical. . . . . *Aptinoderus* Hubenthal

2'. Integument brown to ferrugineous, apical articles of labial and maxillary palpi swollen proximally, acuminate and fusiform toward apex . . . .*Brachinulus* Basilewsky

4.342 Genus *Aptinoderus* Hubenthal

Aptinoderus Hubenthal, 1919:332. *Type species*.—*Brachynus funebris* Peringuey, 1898:320. (Here designated).

Brachynomorphus Hubenthal, 1919:335. *Type species*.—*Brachynus tibialis* Peringuey, 1898:321. (Here designated). NEW SYNONYMY.

Diagnostic combination.—Integument black; dorsum of head and pronotum with large, deeply impressed setiferous punctures; antennal article 3 subequal to articles 1 and 2 combined; anterior coxal cavities closed behind, proepimeron inserted into "notch" on prosternal process; male anterior tarsal articles asymmetrical, vestiture beneath diagonally arranged; subterminal spur of anterior tibia external on top of comb emargination; apterous; humeri strongly sloped; apical membrane of elytra narrower than sutural flange; endophallus without virga or sclerites.

Description.—Medium-sized beetles, about 10.0 to 11.0 mm (Hubenthal, 1919).

Color. Black, with legs and outer antennal articles ferruginous. Elytra black (except in *cyanipennis*, according to Hubenthal, 1919).

Microsculpture. Isodiametric, mostly effaced on head and pronotum, slightly beaded on elytra.

Macrosculpture. Dorsum of head and pronotum coursely and densely punctate, each puncture setiferous.

Head. As in subgenus Brachinus, except center of mentum convex.

Prothorax. As in subgenus Brachinus, except anterior coxal cavities closed behind, proepimeron inserted into "notch" of prosternal process.

Pterothorax. As in subgenus Brachinus, except metasternum short, shorter than longitudinal diameter of middle coxae; metepisternum short; apterous; humeri strongly sloped; apical fringe of elytra consisting of short, closely spaced setae.

Abdomen. As in subgenus Brachinus.

Genitalia. As in subgenus Brachinus, except both parameres small, more balteate. Female as in subgenus Brachinus.

Etymology.—Aptinus = another genus of bombardier beetles; Greek, deros = skin; referring to the black, Aptinus-like integument of these beetles.

Distribution.—The range of this genus is restricted to extreme southern Africa.

4.343 Genus Brachinulus Basilewsky

Brachinulus Basilewsky, 1958:96. Type species—Brachinulus viettei Basilewsky, 1958:97. (Original designation and by monotypy). For details see above and Basilewsky 1962a:126.

Diagnostic combination.—Terminal palpal article swollen proximally, acuminate and fusiform toward apex; apical elytral membrane narrower than sutural flange, and with numerous small, and closely spaced apical setae.

Description.—Small-sized beetles, 5.0 mm. I have not seen specimens of this group, nor does Basilewsky provide information on the characteristics which I have utilized for other species.

Etymology.—*Brachinus* = another genus of bombardier beetles; Latin, *ulus* = small; referring to the small, but *Brachinus*-like form of these beetles.

Distribution.—These beetles are found only on Isla Principe, off the west coast of Africa.

4.344 Genus *Brachinus* Weber

Brachinus Weber, 1801:22. *Type species*.—*Carabus crepitans* Linné, 1758:414. (Subsequent designation, by Latreille, 1810:426).

Brachynus (of authors). (Unjustified emendation by Ahrens, 1812: t. 9).

Aploa Hope, 1833:91. *Type species*.—*Aploa pictus* Hope, 1833:91. (By monotypy).

Pseudaptinus Porta, 1909:90 (*nec* Castelnau). *Type species*.—*Brachinus italicus* Dejean, 1831:409. (Subsequent designation, by Jeannel, 1942:1105).

Cnecostolus Reitter, 1919:133. *Type species*.—*Carabus exhalans* Rossi, 1792:84. (Subsequent designation, by Jeannel, 1942:1105).

Brachynolomus Reitter, 1919:133. *Type species*.—*Brachinus immaculicornis* Dejean, 1826:466. (Subsequent designation, by Jeannel, 1942:1105).

Brachynidius Reitter, 1919:133. *Type species*.—*Carabus sclopeta* Fabricius, 1792:136. (Subsequent designation, by Jeannel, 1942:1105).

Brachinoaptinus Lutshnik, 1926:43. New name for _Pseudaptinus_ Porta (_nec_ Castelnau).

Aptinomimus Alluaud, 1935:25. _Type species_.—_Pheropsophus microrrhabdus_ Alluaud, 1899:381. (Original designation).

Brachynaptinus Csiki, 1933:1628. (Unjustified emendation).

Metabrachinus Jeannel, 1949:1100. _Type species_.—_Brachinus connectus_ Dejean, 1831:417. (Original designation).

Platybrachinus Jeannel, 1949:1100. _Type species_.—_Pheropsophus fasciatocollis_ Fairmaire, 1901:129. (Original designation and by monotypy).

Note.—Much confusion has resulted from the two different ways in which _Brachinus_ (=_Brachynus_) is spelled. The name is derived from the Greek _brachyus_, meaning short, and refers to the truncate elytra. A correct transliteration of the word results in the name _Brachynus_, however, Weber used _Brachinus_ when he erected the genus (1801:22). According to the International Rules of Zoological Nomenclature (Articles 31a, 32c, and 33a), the Law of Priority dictates that the name used must be as Weber first used it, that is _Brachinus_.

Diagnostic combination.—As given in the key.

This genus included the subgenera _Brachinus_ Weber, _Aploa_ Hope, _Cnecostolus_ Reitter, _Brachynolomus_ Reitter, _Brachinoaptinus_ Lutshnik, _Aptinominus_ Alluaud, _Metabrachinus_ Jeannel, and _Neobrachinus_ new subgenus.

4.3441 Key to the Subgenera of the Genus _Brachinus_

Note.—At least four unnamed lineages are not included in this key, see Section 7 for details.

1. Apical edge of apical membrane of elytron with long widely spaced setae, the latter longer than width of membrane, and membrane with closely spaced fringe of shorter setae. . . . .

. . . . Brachinus sensu stricto

1'. Apical membrane without long, widely spaced setae; fringe of shorter setae present or not. 2

2(1'). Elytra with spotted or variegated color pattern 3

2'. Elytra concolorous or with sutural stripe contrasting in color with disc 5

3(2). Antennal article 3 longer than articles 1 and 2 combined; anterior coxal cavities closed behind with prosternal process overlapped by proepimera. . . . . Metabrachinus Jeannel

3'. Antennal article 3 subequal to articles 1 and 2 combined; anterior coxal cavities closed behind with proepimeron inserted into notch or socket of prosternal process. 4

4(3'). Upper spur of anterior tibia external . . . Cnecostolus Reitter

4'. Upper spur slightly internal or in intermediate position. . . . . Aploa Hope

5(2'). Antennal article 3 longer than articles 1 and 2 combined. . . 6

5'. Antennal article 3 subequal to articles 1 and 2 combined. . . 7

6(5). Range limited to New World and Sikkim. . . Neobrachinus new subgenus

6'. Range limited to Madagascar . . . . Aptinomimus Alluaud

7(5'). Upper spur of anterior tibia slightly internal; apical membrane of elytron without setae; humeri sloping; wingless. . . . . .Brachinoaptinus Lutshnik

7'. Upper spur of anterior tibia external; apical membrane of elytron with fringe of setae; humeri square, prominent; winged . . . . Brachynolomus Reitter

4.3442 Subgenus Brachinus Weber

(Fig. 23)

Diagnostic combination.—Antennal article 3 subequal to articles 1 and 2 combined; anterior coxal cavities closed behind, proepimeron overlapping prosternal process; male anterior tarsal articles 1-3 with vestiture beneath diagonally arranged; apical membranes of elytra with several widely spaced setae, each longer than the apical membrane; left paramere large and triangulate; internal sac without virga or other sclerites.

Description.—Small to medium-sized beetles, 4.6 to 9.0 mm.

Color. Ferrugineous, with metallic blue elytra and epipleura. Various sclerites infuscated or not.

Microsculpture. Isodiametric on head, pronotum, and elytra.

Macrosculpture. Head at vertex, pronotum, and elytral depression usually rugose and punctate.

Head. Labrum entire, with six setae transversely arranged on disc. Clypeus rectangular, with two setae, one each side near middle, and numerous smaller setae scattered over disc. Front smooth, with a few scattered setae; furrows shallow; bead over eye continuous to behind eye; one supraorbital seta over each eye; eyes usually prominent. Antennae long, filiform, pubescent throughout, pubescence denser on articles 3-11 than on 1 and 2. Article 3 subequal to articles 1 and 2 combined. Mandibles (as in fig. 8) each broad, triangular, curved at tip, cutting edge with one terebral tooth, and four retinacular teeth; ventral groove with short golden setae; scrobes plurisetose. Labial palpi (as in fig. 13) each filiform;

terminal article slightly swollen, with scattered pubescence; penultimate article plurisetose. Maxillary palpi (as in fig. 9) each filiform, all articles pubescent. Ligula (as in fig. 13) membranous and square, center ventrally produced into a setose sclerotized convexity. Mentum (as in fig. 13) well developed, without tooth; center slightly concave or convex. Gula (as in fig. 13) widened behind.

Prothorax. As described under Subtribe Brachinina. Anterior tibia (as in fig. 33) with subterminal spur slightly internal. Male anterior tarsal articles (as in fig. 41) 1-3 asymmetrical, vestiture beneath consisting of two diagonal, but parallel rows of setae. Setae of vestiture spatulate, truncate, and rolled at apex. Female anterior tarsal articles symmetrical, vestiture absent.

Pterothorax. As described under Subtribe Brachinina.

Abdomen. As described under Division Brachinida.

Genitalia. Male with asymmetrical balteate parameres, the left large and triangulate, the right minute; median lobe various, but nearly symmetrical; ligule single, usually well defined; endophallus moderately long, without sclerites or virga. Female as in subgenus <u>Neobrachinus</u>.

<u>Etymology</u>.—Greek, <u>brachyus</u> = short; referring to the short truncate elytra of these beetles.

<u>Distribution</u>.—The range of this subgenus extends throughout Europe and North Africa.

4.3443 Subgenus Brachynolomus Reitter

(Fig. 41)

Brachynidius Reitter, 1919:133. NEW SYNONYMY.

Diagnostic combination.—Antennal article 3 subequal to articles 1 and 2 combined; anterior coxal cavities closed behind, proepimeron overlapping prosternal process; apical membrane of elytra with numerous closely spaced setae, shorter than apical membrane; both parameres small, balteate; male anterior tarsal articles asymmetrical; vestiture beneath diagonally arranged; internal sac of median lobe with virga surrounding the gonopore.

Description.—Small to medium-sized beetles, about 4.5 to 10.0 mm (Jeannel, 1942).

Color. As in subgenus Brachinus, except some species with a ferrugineous sutural stripe on elytra, and elytra usually vividly metallic.

Microsculpture. As in subgenus Brachinus.

Macrosculpture. As in subgenus Brachinus.

Head. As in subgenus Brachinus.

Prothorax. As in subgenus Brachinus.

Pterothorax. As in subgenus Brachinus.

Abdomen. As in subgenus Brachinus.

Genitalia. Male as in subgenus Brachinus, except both parameres small, more balteate; endophallus with an apical virga. Female as in subgenus Neobrachinus.

Etymology.—Greek, brachyus = short; lomo = fringe; referring to the fringe of setae on the apical membrane of the short elytra.

Distribution.—The range of this subgenus extends from northwestern Africa into southern Europe, and east to Japan.

4.3444 Subgenus Metabrachinus Jeannel

Platybrachinus Jeannel, 1949:1100. NEW SYNONYMY.

Diagnostic combination.—Antennal article 3 longer than 1 and 2 combined; anterior coxal cavities closed behind, proepimeron overlapping prosternal process; male anterior tarsal articles asymmetrical, but less so than in subgenus Brachinus; elytra spotted; apical membrane of elytron without setae; apical elytral membrane wide, wider than sutural flange; internal sac without virga or sclerites.

Description.—Medium to large-sized beetles, 7.0 to 20.0 mm (Jeannel, 1949).

Color. As in subgenus Brachinus, except elytra with spotted color pattern, epipleura usually yellow.

Microsculpture. As in subgenus Brachinus.

Macrosculpture. As in subgenus Brachinus.

Head. As in subgenus Brachinus, except mentum always convex at middle, and antennal article 3 as described above.

Prothorax. As in subgenus Brachinus.

Pterothorax. As in subgenus Brachinus, except costae of elytra sharper, more elevated.

Abdomen. As in subgenus Brachinus.

Genitalia. Male as in subgenus Brachinus, except left parameres small and more balteate. Female as in subgenus Neobrachinus.

Etymology.—Greek, meta = implying change; Brachinus, the common

European genus; referring to Jeannel's idea that these beetles had diverged from the main Brachinus line of evolution.

Distribution.—The range of this subgenus extends throughout southern Africa and Madagascar.

4.3445 Subgenus Aploa Hope

(Figs. 1, 9, 15, 31, 37, 46, 60, 65, 66)

Diagnostic combination.—Antennal article 3 subequal to articles 1 and 2 combined; anterior coxal cavities closed behind, proepimeron inserted into notch of prosternal process; subterminal spur of anterior tibia intermediately positioned on top of comb emargination; male anterior tarsal articles symmetrical; apical membrane of elytra without setae; parameres of male genitalia small, balteate; ligule single, small; endophallus with heavily sclerotized and pigmented subapical knife-shaped sclerite; valvifer of female genitalia glabrous; styli short, spatulate.

Description.—Medium-sized beetles, 12.0 to 14.0 mm.

Color. Generally yellow to testaceous, with black elytral markings.

Microsculpture. Isodiametric on head, pronotum, and elytra, almost effaced on head.

Macrosculpture. None.

Prothorax. As in subgenus Brachinus, except anterior tibiae (fig. 37) each with subterminal spur in intermediate position at top of comb emargination. Male anterior tarsal articles (fig. 46) 1-3 symmetrical, vestiture beneath consisting of two parallel rows of spatulate setae. Female anterior tarsal articles symmetrical,

vestiture absent.

Pterothorax. As in subgenus Brachinus.

Abdomen. As described for Division Brachinida.

Genitalia. Male (fig. 65, 66) with small balteate, asymmetrical, parameres; median lobe variable, but nearly symmetrical; ligule single, small, and narrow; endophallus short, with one large sclerite near apex; virga absent. Female with short, narrow, spatulate, slightly curved, unarmed styli; coxites small, robust; valvifers glabrous; bursa unarmed.

Etymology.—Greek, haploos = single or simple; probably in reference to Hope's knowledge of only one species of this genus.

Distribution.—The range of this subgenus extends on both sides of the equator in the Old World. South of the equator the species are confined to southern Africa. In the north they occur around the periphery of the Sahara Desert, and in (parts of) the Middle East, southern Europe, India, and Ceylon.

4.3446 Subgenus Brachinoaptinus Lutshnik

Pseudaptinus Porta, 1909:90 (nec Castelnau). Primary homonym of Pseudaptinus Castelnau, 1834:36, another genus of Carabidae.

Diagnostic combination.—Antennal article 3 subequal to articles 1 and 2 combined; anterior coxal cavity closed behind, proepimeron inserted into socket of prosternal process; subterminal spur of anterior tibia slightly internal on top of comb emargination; male anterior tarsal articles symmetrical; apical membrane of elytra without setae; apterous, humeri strongly sloping; both parameres of male genitalia small, balteate; endophallus without virga or sclerites.

Description.—Small to medium-sized beetles 4.5 to 11.0 mm.

Color. As in subgenus *Brachinus*. At least one species (*Brachinus pygmaeus* Dejean) has members which are partially depigmented, pale brown throughout.

Microsculpture. As in subgenus *Brachinus*.

Macrosculpture. As in subgenus *Brachinus*.

Head. As in subgenus *Brachinus*, except eyes smaller, not so convex; extremely reduced in *Brachinus pygmaus* Dejean.

Prothorax. As in subgenus *Brachinus*, except as noted in diagnosis.

Pterothorax. As in subgenus *Brachinus*, except metasternum short, subequal to or shorter than longitudinal diameter of middle coxa; humeri sloping, wings absent or greatly reduced.

Abdomen. As in subgenus *Brachinus*.

Genitalia. Male as in subgenus *Brachinus*, except both parameres small, strongly balteate; endophallus without virga or sclerites. Female as in subgenus *Brachinus*.

Etymology.—Greek, *brachyus* = short; *apten* = unable to fly; referring to the *Brachinus* species that cannot fly.

Distribution.—The range of this subgenus extends around the Mediterranean Sea.

4.3447 Subgenus *Aptinomimus* Alluaud

Diagnostic combination.—Antennal article 3 elongate, longer than 1 and 2 combined; anterior coxal cavities closed behind, proepimeron

inserted into notch in prosternal process; subterminal spur of anterior tibiae external on top of comb emargination; male anterior tarsal articles with ventral vestiture longitudinally arranged (according to Jeannel, 1949); endophallus not seen.

Description.—Medium to large-sized beetles, 9.5 to 22.0 mm (Jeannel, 1949).

Color. Brown, sometimes head and pronotum more ferrugineous; legs ferrugineous; elytra and epipeura brown.

Microsculpture. As in subgenus *Brachinus*.

Macrosculpture. As in subgenus *Brachinus*.

Head. As in *Brachinus* (*sensu stricto*), except terminal palpal article widened toward apex; antennal article 3 longer than articles 1 and 2 combined.

Prothorax. As in subgenus *Brachinus*, except anterior coxal cavities closed behind, proepimeron inserted into "notch" in prosternal process.

Pterothorax. As in *Brachinus* (*sensu stricto*), except metasternum short, subequal or shorter than longitudinal diameter of middle coxa; metepisternum short; humeri strongly sloping; wings absent; apical membrane with very short closely spaced setae.

Abdomen. As in subgenus *Brachinus*.

Genitalia. Male (see Jeannel, 1949:1112, fig. 544 a-f) as in subgenus *Brachinus* except both parameres small. Female as in subgenus *Brachinus*.

Etymology.—Greek, *apten* = unable to fly; *mimos* = imitator, mimic; referring to the superficially similar appearance of these beetles to members of the genus *Aptinus*.

Distribution.—This subgenus is restricted to Madagascar.

4.3448 Subgenus *Cnecostolus* Reitter

Diagnostic combination.—Antennal article 3 subequal to articles 1 and 2 combined; anterior coxal cavities closed behind, proepimeron inserted into "notch" of prosternal process; subterminal spur of anterior tibia external on top of comb emargination; male anterior tarsal articles with ventral vestiture longitudinally arranged; apical membrane of elytron without setae; both parameres of male genitalia small, balteate; internal sac with virga around gonopore.

Description.—Small to medium-sized beetles, about 4.0 to 12.0 mm (Jeannel, 1942; Reitter, 1919).

Color. As in subgenus *Brachinus*, except elytra with spotted color pattern, at least one species (*Brachinus cruciatus* Quensel) with brown head and pronotum.

Microsculpture. As in subgenus *Brachinus*.

Macrosculpture. As in subgenus *Brachinus*.

Head. As in subgenus *Brachinus*.

Prothorax. As in subgenus *Brachinus*, except anterior coxal cavities closed by "notch" insertion of proepimeron into prosternal process; male anterior tarsal articles with longitudinally arranged vestiture beneath.

Pterothorax. As in subgenus *Brachinus*, except apical membrane of elytra without fringe of setae.

Abdomen. As in subgenus *Brachinus*.

Genitalia. Male as in subgenus *Brachinus*, except both parameres small, more balteate; endophallus with apical virga around gonopore.

Female as in subgenus Brachinus.

Etymology.—Greek, knekos = yellow; stola = folds; referring to the yellow spots of the costate elytra of these beetles.

Distribution.—The range of this subgenus extends from southern Europe (France), east to at least Mongolia, mostly in more northerly latitudes.

4.3449 Subgenus Neobrachinus new subgenus

Type species.—Carabus fumans Fabricuus, 1781:307, here designated.

Diagnostic combination.—Antennal article 3 longer than articles 1 and 2 combined; anterior coxal cavities closed behind, proepimeron inserted into socket of prosternal process; male anterior tarsal articles with ventral vestiture longitudinally arranged; apical membrane of elytra with numerous, closely spaced, short setae; both parameres small, balteate, the left larger than the right; endophallus with a virga surrounding the gonopore.

Description.—Small to large-sized beetles, 4.8 to 18.5 mm.

Color. Variable, but usually head and prothorax ferrugineous and elytra blue or brown.

Microsculpture. As in subgenus Brachinus.

Macrosculpture. As in subgenus Brachinus.

Head. As in subgenus Brachinus, except mentum of some species with one or two pits surrounded by setae; antennal article 3 longer than articles 1 and 2 combined.

Prothorax. As in subgenus Brachinus, except anterior coxal cavities closed behind, proepimeron inserted into socket in prosternal process.

Pterothorax. As in subgenus Brachinus, except some species apterous as in members of subgenus Brachinoaptinus.

Abdomen. As in subgenus Brachinus.

Genitalia. As in subgenus Brachinus, except both parameres small, more balteate, and left larger than right; virga present at tip of endophallus. Female as in subgenus Brachinus.

Etymology.—Greek, neo = new or most recent; brachyus = short; referring to the probability that these beetles are the most recently derived of an Old World stock that invaded the New World.

Distribution.—The range of this subgenus extends throughout the New World from about 52° N to 40° S latitude. One relict species occurs in Sikkim, in the Himalaya Mountains.

4.4 Key to bombardier beetles of North and Middle America

4.41 Characteristics used in the keys

The more "difficult to use" characteristics in the key are further discussed here to facilitate understanding and utilization of the key. (See also Section 3, "Comparative Morphology").

Color differences are very useful in the identification of bombardier beetles, especially those of North and Middle America. For the most part, I have used the presence or absence of a color on various sclerites, rather than comparing shades of colors. Shades of color are used for the elytra only, and only in a very few species is the variation of color so great that this characteristic is useless for identification. In most cases, color combinations are constant. Very teneral adults will not have color pigments deposited yet, but

these are rarely collected.

In North and Middle America the head of Brachinus beetles is usually ferrugineous, but four Neotropical species have brown heads, and one eastern United States species has a black head. The mouth parts generally match the color of the head, but in four species with ferrugineous head color, the palpi are infuscated or black. The antennal articles 2 to 4 are quite variable, ranging from ferrugineous to black, with intermediate stages of infuscated apically and totally infuscated. The scape matches the head color. Antennal articles 5-11 are usually dusky in ferrugineous colored species, but specimens of some species have infuscated lateral stripes on each article, or each article is entirely infuscated.

The prothorax always matches the color of the head. The elytra are either blue, brown, black, green, or slate-colored. In some species the epipleura of some specimens are testaceous, but usually the epipleura match the elytral color. The sutural costa varies from ferrugineous to black. In two species in the study area, the ferrugineous color includes two costae and their adjacent depressions.

The venter is usually ferrugineous at the middle of the mesosterna and metasterna. The sides of the metasterna, mesepisterna, mesepimera, metepisterna, and the abdominal sterna and terga may be ferrugineous, infuscated, black, or (in two species) black with metallic blue luster. In species without the ferrugineous ground color, the various ventral sclerites are either infuscated or not. In species with black abdomens, the paramedial "dimples" are usually ferrugineous. The legs may be either ferrugineous, testaceous, brown, or black. Usually, testaceous colored legs have infuscated "knees" or femoral apices.

This knee color also occurs in some ferrugineous-legged species. In some ferrugineous species, the tibiae and tarsi may be infuscated or black, and occasionally the femora also may be black.

Characteristics of pubescence and density of setae are very useful in species identification. The number of setae on the mentum and submentum of North and Middle American bombardier beetles is variable. Usually, the mentum has two long setae (fig. 19), and the submentum has about 8 to 12 setae transversely arranged (fig. 19). A second type of setal arrangement is when the center of the mentum has a small patch of setae (fig. 21). One or two setae do not constitute a patch. A third type of setal arrangement is when the setae of the submentum are twice as abundant (about 16-24). A fourth type of setal arrangement is when there is a patch on the mentum, and also a doubling of the number of submental setae (fig. 21).

The setal arrangement on the proepisternum and proepipleura (=hypomera, Habu 1967) is useful for identifying members of many species. Several combinations of setal patterns may occur on these sclerites. In members of some species, the setae are so numerous that they constitute pubescence. In others, only one or two setae occur on the entire lateral side of the prothorax. Members of some species have a few scattered setae both anteriorly and posteriorly on each lateral sclerite of the prothorax. In other species, the proepipleuron is glabrous, while the proepisternum has setae both anteriorly and posteriorly. In members of a few species, the proepisternum is completely pubescent, while the proepipleuron is glabrous.

The pattern of short pubescence on the elytra is used very frequently in the following key to North and Middle American bombardier

beetles. In all species, erect depression setae, eighth interval umbilicate setae, and scutellar umbilicate setae are present, in addition to the short, densely placed setae that are referred to below as "pubescence." Several elytral patterns of pubescence are exhibited. In most species the elytra are completely pubescent. In others, the pubescence is restricted to the depressions between the costae, while the costae are smooth and glabrous. In some western species, the pubescence is restricted to intervals (area between rows of erect depression setae) 6, 7, and 8 at the middle of the elytra, but also occurs around the scutellar region and extends completely across the elytra in the apical sixth. An even greater decrease in the amount of pubescence is seen in other western and tropical species, where it is restricted to the 8th interval, and the scutellar region. Only the members of Brachinus costipennis Motschulsky have entirely glabrous elytra.

The macrosculpture of the anterior surface of the anterior tibia is used in a few cases to differentiate species. Normally the surface is densely strigose with the strigae extending longitudinally, however, in a few species the surface is smooth except for some small punctures. In others, the punctures are elongate and coalesce, resulting in a condition that looks like shallow strigae.

The height of the elytral costae is used to differentiate a few species. It is a difficult character to describe, but is not hard to see.

The most important characteristics are those of the male genitalia. To identify males of many species, the apex of the shaft is all that need be observed. To identify males of some species the

virga of the endophallus must be examined. I have illustrated the male genitalia of all species in which the male is known. The illustrations should be used in conjunction with the descriptions provided in Section 4.5, and can be relied upon to provide an absolute identification.

4.42 Key to the species of Brachinus and Pheropsophidius of North and Middle America

1. Mandibles with unisetose scrobes; suture present between proepisternum and proepimeron (Pheropsophidius) 2

1'. Mandibles with plurisetose scrobes; no suture between proepisternum and proepimeron (Brachinus) 3

2(1). Elytron with all intervals strongly costate; depressions between costae minutely but coarsely sculptured; wings fully developed . . . . *P.* (*Pheropsophidius*) *aequinoctialis* (Linné), p. 363

2'. Elytron with intervals 5-8 strongly costate at apex, and interval 8 costate just behind humerus, otherwise scarcely costate; each elytron with a large orange spot at center; wingless. . . . . *P.* (*Protopheropsophus*) *biplagiatus* Chaudoir, p. 361

3(1'). Elytron with ferrugineous sutural stripe, contrasting strongly with the otherwise darkly colored disc; elytral epipleura pale 4

3'. Elytra concolorous, epipleura pale or dark 5

4(3). Legs (at least tibiae) pale, with dark knees; palpi pale; elytra usually greenish . . . *B.* *cinctipennis* Chevrolat, p. 200

4'. Legs totally black; palpi infuscated to black; elytra usually bright blue . . . . *B. cibolensis* new species, p. 202

5(3'). Head, prothorax, and elytra concolorous, either black or brown 6

5'. Head and prothorax testaceous or ferrugineous, strongly contrasting with darkly colored elytra 9

6(5). Body completely black; elytra black with blue luster; wingless. *B. capnicus* new species, p. 114

6'. Body brownish with testaceous legs and infuscated knees; winged. 7

7(6'). Mentum with two pits surrounded by numerous long setae (fig. 20) . . . . *B. sallei* Chaudoir, p. 137

7'. Mentum flat to shallowly biconcave, with only two setae . . . 8

8(7'). Elytral pubescence confined to depression 8 (Mexico) . . . . *B. melanarthrus* Chaudoir, p. 141

8'. Elytral pubescence not confined to depression 8 (Greater Antilles) . . . . *B. brunneus* Castelnau, p. 140

9(5'). Mentum with a large deep median sulcus surrounded by a ring of setae (fig. 18) 10

9'. Mentum flat to shallowly biconcave OR with two shallow lateral pits (fig. 19). 11

10(9). Elytra glabrous; venter ferrugineous. . . . . *B. costipennis* Motschulsky, p. 171

10'. Elytra pubescent; venter mostly infuscated. . . . . *B. mobilis* new species, p. 348

11(9'). Wings rudimentary, each a narrow elongate pad; metasternum short between middle and hind coxae, no longer than diameter of

middle coxa (fig. 26); humeri strongly sloped (fig. 72). 12

11'. Wing with at least reflexed apex; metasternum longer than diameter of middle coxa; humeri sloped, square (fig. 98) or protruding 14

12(11). Abdomen, metepisterna, and sides of metasternum infuscated to black; abdominal sterna with ferrugineous paramedian dimples; mentum without central setal patch (fig. 19) 13

12'. Abdomen infuscated only at sides, rest of venter ferrugineous; paramedian dimples not of a contrasting color; mentum with central setal patch (fig. 21) . . . . .B. _microamericanus_ new species, p. 112

13(12). Submentum densely setiferous (16 or more setae, fig. 21); larger, more robust beetles; antennae ferrugineous. . . . . B. _americanus_ (LeConte), p. 107

13'. Submentum sparsely setiferous (10 or less, fig. 19); smaller beetles; antennal articles 3 and 4 infuscated . . . . .B. _alexiguus_ new species, p. 111

14(11'). Elytra brown; legs pale testaceous with dark knees. 15

14'. Elytra blue, blue-black, greenish-blue, or slate colored; legs concolorous without darkly colored knees, or ferrugineous with darkly colored knees. 22

15(14). Proepipleura and proepisterna pubescent throughout; venter pale; elytra not true brown . . . . B. _sonorous_ new species, p. 354

15'. Proepipleura glabrous; proepisterna with only a few scattered setae anteriorly and/or posteriorly, or glabrous. 16

16(15'). Elytral epipleura at least at humerus pale testaceous, strongly contrasting with elytral color 17

16'. Elytral epipleura and disc of elytra concolorous. 19

17(16). Metasternum at sides usually infuscated; elytral disc glabrous; median lobe (figs. 156, 157, 158); stylus (fig. 145); in United States, west of Rocky Mountains only . . . . B. lateralis Dejean, p. 148

17'. Metasternum not infuscated at sides; elytral disc usually sparsely pubescent; in United States, east of Rocky Mountains only. 18

18(17'). Anterior third of proepisternum with a few setae; median lobe (figs. 153, 154, 155); stylus (fig. 142); range—United States, Mexico, Central America, and Cuba. . . . . B. adustipennis new species, p. 159

18'. Anterior third of proepisternum glabrous; median lobe (figs. 147, 148, 149); stylus (fig. 144); range—Mexico, South America . . . . B. aeger Chaudoir, p. 152

19(16'). Larger beetles, greater than 15.0 mm in length. . . . . B. grandis Brullé, p. 143

19'. Smaller beetles, less than 12.0 mm in length. 20

20(19'). Elytra prominently costate; median lobe (figs. 159, 160, 161); stylus (fig. 143) . . . . B. chalchihuitlicue new species, p. 154

20'. Elytra almost smooth, costae barely elevated. 21

21(20'). Median lobe (figs. 150, 151, 152); stylus (fig. 146); elytral pubescence usually extensive, covering apical third of elytra . . . . B. arboreus Chevrolat, p. 156

21'. Median lobe (figs. 162, 163, 164); stylus (fig. 141); elytral pubescence usually discontinuous near middle of apical third of elytra . . . . . . B. chirriador new species, p. 157

22(14'). Elytral pubescence in outer depressions 6, 7, 8, or just in 8; less dense pubescence usually across apical third of elytra and sometimes in the vicinity of scutellum 23

22'. Elytral pubescence all along depressions between costae, usually costae pubescent. 28

23(22). Elytral pubescence confined to depression 8, behind humerus and at middle, although setae may be scattered across the apical sixth of the elytra. 24

23'. Elytral pubescence in depressions 6, 7, and 8, and across the apical sixth of the elytra. 25

24(23). Venter mostly ferrugineous, except for infuscated metepisterna and (sometimes) sides of abdomen; elytral costae prominent; microsculpture of pronotum isodiametric, surface rugose and shining. . . . .B. gebhardis Erwin, p. 281

24'. Venter infuscated; elytral costae barely elevated; microsculpture of pronotum granulate, surface rugose and dull, color milky ferrugineous. . . . . B. galactoderus new species, p. 284

25(23'). Tarsi, tibiae, and apices of femora infuscated to black . . . . .B. rhytiderus Chaudoir, p. 122

25'. Tarsi, tibiae, and femora ferrugineous. 26

26(25'). Venter and antennae ferrugineous. . . . . *B. pallidus* Erwin, p. 197

26'. Venter and usually antennal articles 3 and 4 infuscated to piceous 27

27(26'). Elytra shiny black, very convex . . . . *B. explosus* new species, p. 350

27'. Elytra blue, microsculpture coarse, surface dull. . . . . *B. mexicanus* Dejean, p. 215

28(22'). Median elevated portion of mentum with a dense patch of setae (fig. 21); submentum densely setiferous (more than 20 setae) 29

28'. Median raised portion of mentum either glabrous or with one or two small setae (fig. 19); submentum various 33

29(28). Metasternum anterior to antecoxal piece, subequal in length to longitudinal diameter of middle coxa (fig. 26); antennal articles 3 and 4 infuscated at least apically; elytra usually greenish. . . . . *B. viridipennis* LeConte, p. 184

29'. Metasternum longer than middle coxa; antennal articles 3 and 4 usually ferrugineous (except some populations of *B. alternans*); elytra usually bluish 30

30(29'). Proepipleura pubescent throughout their length; proepisterna completely pubescent .31

30'. Proepipleura and proepisterna pubescent only anteriorly and posteriorly, glabrous at middle . . . . *B. perplexus* Dejean, p. 305

31(30). Anterior tibia with anterior surface coarsely strigose; elytral costae barely elevated. 32

31'. Anterior tibia with anterior surface punctate, rarely with punctures coalescing; elytral costae very pronounced, easily visible with unaided eye. . . . . B. alternans Dejean, p. 177

32(31). Humeral angles square (fig. 98) prominent; elytra broad and quadrate with lateral margins behind humeri straight to at least middle. . . . . .B. imperialensis Erwin, p. 309

32'. Humeri rounded, not at all prominent; elytra narrow, with lateral margins behind humeri evenly arcuate entirely to apex. . . . . .B. velutinus Erwin, p. 307

33(28'). Abdominal sterna entirely ferrugineous OR infuscated only marginally, with a pale center extending to apex OR mostly ferrugineous except for infuscated lateral margins and sternum 6 34

33'. Abdominal sterna infuscated to piceous, rarely center of sterna 2 and 3 paler, but usually not equal in color to the hind coxae. 46

34(33). Erect depression setae at least twice as long as elytral pubescence. . . . . .B. cyanipennis Say, p. 267

34'. Erect setae subequal to or shorter than elytral pubescence 35

35(34'). Abdominal sterna completely ferrugineous. 36

35'. Abdominal sterna with infuscated margins. 37

36(35). Proepipleura glabrous; proepisterna with a few scattered setae; antennae ferrugineous. . . . . .B. janthinipennis (Dejean), p. 339

36'. Proepipleura pubescent; proepisterna pubescent; antennal articles 3 and 4 infuscated . . . . _B._ _sonorous_ new species, p. 354

37(35'). Pronotum without lateral seta at middle 38

37'. Pronotum with lateral setae present 40

38(37). Proepipleura densely pubescent throughout their length. . .39

38'. Proepipleura with at most a few setae anteriorly. . . . . _B._ _kansanus_ LeConte, p. 168

39(38). Elytral depression 1 with erect depression setae at least twice as long as elytral pubescence; pronotum not densely pubescent . . . . _B._ _oaxacensis_ new species, p. 249

39'. Elytral depression 1 with short depression setae; pronotum densely pubescent . . . . _B._ _hirsutus_ Bates, p. 193

40(37'). Elytra moderately to strongly costate 41

40'. Elytra barely costate, almost smooth. . . . . _B._ _ovipennis_ LeConte, p. 255

41(40). Pronotum completely pubescent 42

41'. Pronotum mostly glabrous, at most with a few scattered setae. . . . . _B._ _rhytiderus_ Chaudoir, p. 122

42(41). Proepipleura glabrous; proepisterna with scattered setae both anteriorly and posteriorly, glabrous medially 43

42'. Proepipleura with at least some setae posteriorly; proepisterna pubescent throughout 44

43(42). Elytra bright blue, usually metallic. . . . . _B._ _elongatulus_ Chaudoir, p. 126

43'. Elytra slate-grey with greenish luster. . . . . _B._ _texanus_ Chaudoir, p. 118

44(42'). Pronotum (fig. 336) densely covered with large pits, surface very rugose; mentum with numerous accessory setae scattered over surface. . . . . B. favicollis Erwin, p. 302

44'. Pronotum (figs. 334-337) at most with fine punctures, not at all rugose; mentum without accessory setae (occasionally one or two small setae at middle) 45

45(44'). Anterior tibia with anterior surface strigose; elytra with costae moderately elevated. . . B. puberulus Chaudoir, p. 301

45'. Anterior tibia with anterior surface punctate, the punctulae sometimes coalescing, but not forming strigae; elytra with highly elevated costae. . . . . . B. fumans Fabricius, p. 289

46(33'). Venter with metallic blue luster, tibiae and tarsi black; antennal articles 2-11 piceous to black; palpi black; elytra brilliant metallic blue. . . . . .B. azureipennis Chaudoir, p. 242

46'. Venter without metallic blue luster, infuscated to blackish or not, otherwise combination of characteristics not as above. 47

47(46'). Proepipleura glabrous 48

47'. Proepipleura with at least a few setae, either throughout their length or at both ends (observe both sides of beetle) 65

48(47). Metasternum infuscated at sides 49

48'. Metasternum not infuscated at sides 60

49(48). Tibiae and tarsi infuscated, at least darker than femora. 50

49'. Tibiae and tarsi concolorous with femora. 51

50(49). Metasternal process (between middle coxae) usually infuscated; antennal article 3 shorter than diameter of eye; median lobe not ridged ventrally (fig. 257); stylus narrow (fig. 275). . . . . *B. phaeocerus* Chaudoir, p. 237

50'. Metasternal process ferrugineous; antennal article 3 longer than diameter of eye; median lobe ridged ventrally (fig. 240) stylus broad, spatulate (fig. 247). . . . . *B. quadripennis* Dejean, p. 207

51(49'). Mesepisterna infuscated to black; elytra strongly costate . . . . *B. tenuicollis* LeConte, p. 262

51'. Mesepisterna not darkly infuscated (if at all); elytra not or only moderately costate. 52

52(51'). Elytra with costae easily visible; elytral pubescence not dense 53

52'. Elytra without costae; elytral pubescence very dense; elytral color dull slate-blue . . . . . *B. sublaevis* Chaudoir, p. 324

53(52). Metasternum subequal in length to diameter of middle coxa; humeri sloped; lateral margin of elytron behind humerus arcuate to apex . . . . *B. patruelis* LeConte, p. 251

53'. Metasternum longer than diameter of middle coxa; humeri square or prominent, margin behind humerus straight at least to middle of elytra 54

54(53'). Anterior tibia with anterior surface punctate, punctulae small, rarely coalescing. 55

54'. Anterior tibia with anterior surface strigose 56

55(54). Median lobe with ventral ridge (fig. 237); stylus acute (fig. 250). . . . . *B. neglectus* LeConte, p. 231

55'. Median lobe without ventral ridge (fig. 404); stylus rounded apically (fig. 410). . . . B. vulcanoides new species, p. 337

56(54'). Proepipleura and proepisterna glabrous (proepisterna rarely with one to three setae along anterior edge) . . . . B. medius Harris, p. 275

56'. Proepipleura and proepisterna with pubescence both anteriorly and posteriorly, glabrous medially. 57

57(56'). Antennal article 3 infuscated throughout 58

57'. Antennal article 3 infuscated apically . . . . B. cyanochroaticus new species, p.320

58(57). Median lobe ridge ventrally (fig. 240); stylus very broad, spatulate (fig. 247) . . . . . B. quadripennis Dejean, p. 207

58'. Median lobe not ridge ventrally; stylus acute apically . .59

59(58'). Range—north of latitude 35° N from New England to Indiana; median lobe (figs. 407, 408, 409); stylus (fig. 411) . . . . B. fulminatus new species, p. 335

59'. Range—south latitude 35° N from Florida to Missouri; median lobe (figs. 398, 399, 400); stylus (fig. 412). . . . . B. oxygonus Chaudoir, p. 332

60(48'). Elytra with major part of pubescence in rows between costae. 61

60'. Elytra with pubescence evenly scattered over surface, costae also pubescent 62

61(60). Elytra bright blue, usually metallic . . . . B. elongatulus Chaudoir, p. 126

61'. Elytra slate-grey with greenish luster . . . . B. texanus Chaudoir, p. 118

62(60'). Proepisterna glabrous, at most with 1-3 setae near anterior edge . . . . B. medius Harris, p. 275

62'. Proepisterna pubescent, at least anteriorly and posteriorly 63

63(62'). Antennal article 3 extensively infuscated (sometimes also article 2) 64

63'. Antennal article 3 ferrugineous (apex of 4 sometimes lightly infuscated) . . . . <u>B</u>. <u>cordicollis</u> Dejean, p. 315

64(63). Humeral angle square, elytral margin behind humerus straight, at least to middle; range—Florida . . . . <u>B</u>. <u>conformis</u> Dejean, p. 253

64'. Humeri sloped, margin behind humerus arcuate to apex; range—Arizona . . . . <u>B</u>. <u>imporcitis</u> new species, p. 240

65(47'). Metasternum infuscated at sides 66

65'. Metasternum not infuscated at sides 68

66(65). Submentum densely setiferous (more than 20 setae); larger beetles, longer than 12.0 mm and wider than 5.0 mm across elytra at widest part . . . . <u>B</u>. <u>javalinopsis</u> new species, p. 228

66'. Submentum sparsely setiferous (10 or less); smaller beetles, less than 11.5 mm in length and 4.9 mm in width 67

67(66'). Knees infuscated; elytral pubescence evenly distributed over surface; pronotum narrow (fig. 421) . . . . <u>B</u>. <u>aabaaba</u> new species, p. 352

67'. Knees not infuscated; elytral pubescence in rows between barely elevated costae; pronotum cordiform (fig. 226) . . . . <u>B</u>. <u>kavanaughi</u> new species, p. 225

68(65'). Outer antennal articles and sutural costa of elytra black, strongly contrasting with color of elytra. . . . . *B. consanguineus* Chaudoir, p. 244

68'. Outer antennal articles ferrugineous and sutural costae of elytra bluish, not contrasting with color of elytra . .69

69(68'). Ligule of median lobe broad, spatulate (fig. 182) stylus very narrow, elongate (fig. 192) . . . . *B. rugipennis* Chaudoir, p.187

69'. Ligule of median lobe paralleliform (fig. 378) stylus wider, shorter (fig. 386) . . . . *B. cordicollis* Dejean, p. 315

4.5 The subgenus *Neobrachinus* new subgenus in North and Middle America

4.51 The *americanus* group

The members of this group are characterized by the following: pouch-shaped virga, enlarged prothorax, and reduced wings together with the modifications of the metathorax. Four species are included, in two subgroups.

4.511 The *americanus* subgroup

The three species included here, *B. americanus* (LeConte), *B. microamericanus* new species, and *B. alexiguus* new species differ from the species included in the following subgroup only in overall color, but this color difference is of major importance. The species included here are similar in color to the majority of North American brachinines, that is, head and pronotum ferrugineous, elytra blue, with

various sclerites infuscated, depending upon the species.

4.5111 Brachinus americanus (LeConte)

(Figs. 71, 79, 80, 81, 87, 88)

Aptinus americanus LeConte, 1844:48. Lectotype, here selected, a female, MCZ red type label number 5839, further labelled with a yellow disc and "72." Type locality.—Georgia, as originally given by LeConte.

Aptinus americanus Dejean, 1836:13. NOMEN NUDUM.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 8.0 to 13.0 mm.

Color. Metepisterna, sometimes metasternum at sides, and abdominal sterna and terga infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows rugose and punctate. Surface of pronotum with numerous setiferous punctures, punctures moderately impressed.

Head. Frontal furrows moderately impressed. Antennal scape nearly cylindrical, widened a little apically. Ligula with sclerotized center area ellipsoid-convex with numerous setae scattered over its surface. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 71) slightly convex, flattened along center line, sides slightly reflexed. Proepipleura glabrous. Proepisterna with a few setae anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior surface punctate.

Pterothorax. Elytra elongate, narrow, moderately costate. Humeri narrow, strongly sloped. Costae smooth, depressions pubescent. Hind wings reduced, elongate pads. Metasternum short, subequal to or shorter than diameter of middle coxa (fig. 26).

Abdomen. As described for genus.

Genitalia. Male (figs. 79, 80, 81). Median lobe with plane of shaft barely rotated from plane of basal bend. Basal bend moderately long. Shaft slightly swollen medially. Apex of shaft narrowed, rounded apically. Ligule short, narrow, rounded apically. Virga (figs. 79, 80). Female (fig. 87). Stylus short, narrow, narrowly rounded at apex.

Variation.—Besides the intrapopulational variation in the shape of the pronotum and total size, these beetles vary in the amount of reduction of the elytral humeri and in the amount of infuscation of the metasterna at the sides.

Flight.—The reduction of wing membrane makes these beetles incapable of flight.

Etymology.—The latinized form of America, the place where the types were collected.

Collecting notes.—W. Whitcomb (per. comm.) collected these beetles in Arkansas corn fields. There is no reason to believe that these beetles are restricted to areas near water (as are other species of *Brachinus* in North America).

Life history.—Members of this species have been collected from February to October. I have seen one teneral specimen collected in September from Hot Springs, Arkansas. Overwintering is probably as an adult as in *B. pallidus* Erwin (Erwin, 1967).

Distribution.—(Fig. 88). The range of this species extends from Texas north to Minnesota, east to New York, and south to Florida. I have seen 440 specimens from the following localities:

UNITED STATES

ALABAMA: Blount County (Blount Springs) CMPP; Fayette County (Berry) UASM; Lee County (5.0 miles north of Auburn) AUAA; Tuscaloosa County (Peterson) UASM. ARKANSAS: Benton County (Rogers) KSU; Garland County (Hot Springs) CAS, SJSC; (Hot Springs-Lake Hamilton) SJSC; Hempstead County (Hope) UMAH; Izard County UAFA; Lawrence County (Imboden) LACM, MCZ; Logan County (Mount Magazine) CNHM; Phillips County (West Helena) UMAH; Polas County (Ouachita Mountains) UASM; Sebastian County (Fort Chaffee) RCGr; Scott County UAFA; Washington County ISNH, UAFA; (Cove Creek Valley) RFre, UAFA; (Goshen) DRWh; (Mount Sequoyah) ISNH; County unknown (Knob Hill Ranch, Ozark Mountains) CAS. FLORIDA: (No locality given) WSUP. GEORGIA: (No locality given) MCZ. ILLINOIS: Alexander County (Olive Branch) CNHM; Champaign County (Urbana) ISNH; Cook County (Chicago area) CNHM, (La Grange) CAS, UMAH, USNH, (Palos Park) CAS, CNHM, UMAH, (Riverside) UMAH, (Summit) CNHM, ISNH, (Willow Springs) CAS, CNHM, UASM, UMAH, ZMLS; Hardin County (Junction Highway 34-146) RTBe; La Salle County RTBe; Putnam County ISNH; Richland County (Olney) ISNH; Will County (Beecher) CNHM; Counties unknown (Bowmanville) CAS, (Falling Spring) LACM. INDIANA: Crawford County CAS; Franklin County (Metamora) UMAH; Harrison County PUM; Jefferson County (Clifty Falls State Park) UASM; Knox County PUM; Lawrence County (Bedford) PUM; Monroe County ISUA, (Bloomington) UMAH; Morgan County (Morgan-Monroe county line) CEWh; Posey County (Hovey Lake) PUM; Ripley County (Versailles) CEWh; Vigo County PUM; County unknown (Pine) UNHM.

IOWA: Boone County (Ledges State Park) ISUA; Dickinson County (Lake Okoboji) ISUA; Johnson County (Iowa City) MCZ; Linn County (Palisades) USNM; County unknown (Foster) USNM. KANSAS: Douglas County (Lawrence) UMAH; Franklin County UMAH. KENTUCKY: Cumberland County (Franklin Branch) TCBa; Edmonson County (2.0 miles from Mammoth Cave) MCZ; Meade County (Fort Knox) UASM; Oldham County (Sleepy Hollow) ULLK; Wayne County (Wolf Creek Lake) ULLK; County unknown (Sanborn) MCZ. MICHIGAN: Monroe County (Monroe) PUM. MINNESOTA: Winona County UMSP. MISSISSIPPI: Leake County (near Ludlow) RCGr; Perry County (Richton) CUNY. MISSOURI: Boone County (Columbia) UNLN; Camden County (Camdenton) UMAH, (Ozark Lake) CAS; Jefferson County (Kimmswick) UMAH; Polk County (Aldrich) CUNY; Saint Charles County (Weldon Springs) UASM; Saint Francis County (Flat River) USNM; Saint Louis County JShu, UASM, (Rockwoods Reservoir) UASM; Teney County (Branson) CAS; Counties unknown (Mincy) ISUA, (Willard) UASM. NEW YORK: Jessamine County UASM. NORTH CAROLINA: Orange County (Chapel Hill) CUNY; Wake County (Raleigh) UNCR. OHIO: Franklin County (Columbus) PUM; Mercer County (Mendon) UMAH; Ottawa County (near Marblehead) UMAH; Washington County (New Matamoras) OUCO; County unknown (Georgeville) OUCO. OKLAHOMA: Latimer County CAS, OSUS; Mayes County (Grand) OSUS; Payne County (Stillwater) OSUS; Pontotoc County OSUS; Tulsa County (Catoosa) CAS. PENNSYLVANIA: Allegheny County CUNY, (Pittsburgh) CMPP; Fayette County (Ohio Pyle) CMPP. TENNESSEE: Davidson County (Nashville) OUCO, USNM. TEXAS: Brazos County (College Station) MCZ, TAMU; Colorado County (Columbus) USNM; Cooke County (Gainsville) USNM; Dallas County (Dallas) MCZ; Kendall County (Comfort) CMPP; Lee County (Fedor) CMPP; McLennan County (Waco)

MCZ; Newton County (Call) USNM. WISCONSIN: Green County (Albany) CEWh; La Crosse County (La Crosse) RESt.

4.5112 Brachinus alexiguus new species

(Figs. 74, 75, 76, 77, 89)

Type locality.—College Station, Texas.

Type specimens.—The holotype male and one paratype male are in the entomological museum at MCZ and CAS, respectively. The holotype was collected at the type locality on March 22, 1927. The paratype was collected in Latimer County, Oklahoma by R. D. Bird on April 25, 1931.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Small-sized beetles, 7.0 to 8.0 mm.

Color. Antennal articles 3 and 4, mesepisterna, metepisterna, metasternum at sides, and abdominal sterna and terga infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and surface of pronotum punctate, punctures shallowly impressed.

Head. As in americanus.

Prothorax. As in americanus. Pronotum (fig. 74).

Pterothorax. As in americanus.

Abdomen. As described for genus.

Genitalia. Male (figs. 75, 76, 77). As in americanus, except median lobe slightly wider toward apex, and ligule more elongate and narrower. Virga (figs. 75, 76). Female unknown.

Variation.—Too few specimens are known to evaluate the geographic

variation.

Flight.—The reduction of wing membrane makes these beetles incapable of flight.

Etymology.—Latin, ala = wing; exiguus = small, short or scanty; referring to the reduced wings of these beetles.

Life history.—The two specimens were collected in March and April, respectively, but neither were teneral.

Distribution.—(Fig. 89). I have seen two specimens from the following localities:

UNITED STATES

OKLAHOMA: Latimer County CAS. TEXAS: Brazos County (College Station) MCZ.

4.5113 Brachinus microamericanus new species

(Figs. 78, 82, 83, 84, 86, 90)

Type locality.—Dundee, Mississippi.

Type specimens.—The holotype male and allotype female are in the entomological museum at AMAH; both were collected by T. H. Hubbell at the type locality on August 13, 1929. Two paratypes are in each of the following collections: CAS, MCZ, TLEr, UASM, UMAH.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Small-sized beetles, 6.0 to 8.7 mm.

Color. Metepisterna and sides of abdomen infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and surface of pronotum slightly

rugose and punctate, punctures shallowly impressed.

Head. As in americanus, except antennal scape robust, widened apically, ligula with three setae in two rows on each side of center area, and mentum and submentum with accessory setae.

Prothorax. As in americanus, except proepipleura with a few setae anteriorly and posteriorly, glabrous medially. Pronotum (fig. 78). Anterior tibia with anterior edge strigose.

Pterothorax. As in americanus.

Abdomen. As described for genus.

Genitalia. Male (figs. 82, 83, 84). Median lobe with plane of shaft rotated about 45° from plane of basal bend. Basal bend short. Apex of shaft narrowed, narrowly rounded apically. Ligule short, narrow, truncate. Virga (figs. 82, 83). Female (fig. 86). Stylus short, angulate, widened apically.

Variation.—The series from Dundee are quite constant in all characteristics, except the accessory setae of the mentum and submentum which vary in number. However, the single specimen from Woodrow is considerably smaller and the shape of its pronotum is different. This specimen may not be conspecific with the others, but further material will have to be obtained before its relationship can be established.

Flight.—As in americanus.

Etymology.—Greek, mikros = small; americanus, nominate species of the group; referring to the resemblance, but smaller form of this species to the nominate species.

Life history.—The Dundee specimens were collected in August and the Woodrow specimen in May, and none were teneral.

Distribution.—(Fig. 90). I have seen 17 specimens from the

from the following localities:

UNITED STATES

MICHIGAN: Huron County (Charity Island) UMAH. MISSISSIPPI: Tunica County (Dundee) UMAH. MISSOURI: County unknown (Woodrow) USNM.

4.512 The capnicus subgroup

The single species included here differs from the previous subgroup in its overall black color. This is the only known black *Neobrachinus*, although some species have black parts, and others are very dark brown.

4.5121 *Brachinus capnicus* new species

(Figs. 72, 73, 85, 91)

Type locality.—Smokemont, Great Smoky Mountains National Park, North Carolina.

Type specimen.—The holotype female is in the entomological museum at CUNY. The single known specimen was collected by W. B. Jones *et al* in 1938.

Diagnostic combination.—This is the only known species with all black members.

Description.—Medium-sized beetle, 10.0 mm.

Color. Black. Elytra black with metallic blue luster.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows rugose and punctate, disc of pronotum punctate, punctures moderately impressed.

Head. As in *americanus*, except submentum with accessory setae.

Prothorax. As in *americanus*, except center of pronotum concave

along midline. Pronotum (fig. 73).

Pterothorax. As in americanus.

Abdomen. As described for genus.

Genitalia. Male unknown. Female (fig. 85). Stylus short, narrow, acute at apex.

Flight.—As in americanus.

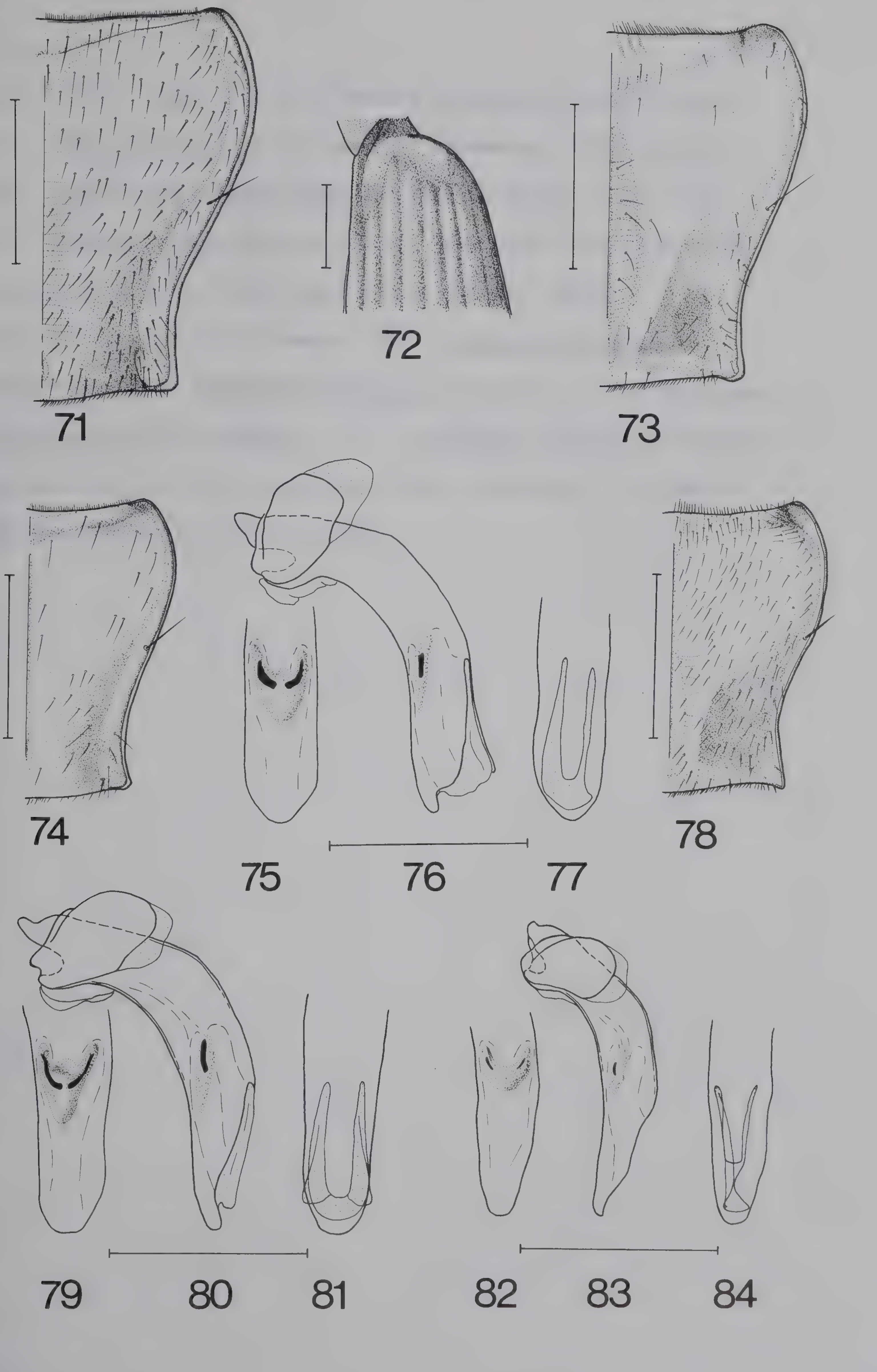
Etymology.—Greek, kapnikos = smoky; referring to the darkly colored integument of these beetles, the place where the type was collected, and the ability of these beetles to crepitate, producing a cloud of "smoke."

Distribution.—(Fig. 91).

UNITED STATES

NORTH CAROLINA: Swain County (Smokemont) CUNY.

Figs. 71, 73, 74, 78. Pronotum, right half, dorsal aspect. 71. *Brachinus americanus* (LeConte), Ludlow, Mississippi. 73. *Brachinus capnicus* new species, Smokemont, North Carolina. 74. *Brachinus alexiguus* new species, College Station, Texas. 78. *Brachinus microamericanus* new species, Dundee, Mississippi. Fig. 72. Right elytron, dorsal aspect of humeral angle, *Brachinus capnicus* new species, Smokemont, North Carolina. Figs. 75-77, 79-84. Male genitalia. 75. *Brachinus alexiguus* new species, College Station Texas, ventral aspect. 76. Lateral aspect of same. 77. Dorsal aspect of same. 79. *Brachinus americanus* (LeConte), Washington County, Arkansas, ventral aspect. 80. Lateral aspect of same. 81. Dorsal aspect of same. 82. *Brachinus microamericanus* new species, Dundee, Mississippi, ventral aspect. 83. Lateral aspect of same. 84. Dorsal aspect of same. Accompanying scale lines equal 1.0 mm.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Figs. 85-87. Right stylus of female ovipositor, ventral aspect. 85. Brachinus capnicus new species, Smokemont, North Carolina. 86. Brachinus microamericanus new species Dundee, Mississippi. 87. Brachinus americanus (LeConte), Washington County, Arkansas. Accompanying scale lines equal 1.0 mm. Figs. 88-91. Geographical distribution maps. 88. Brachinus americanus (LeConte). 89. Brachinus alexiguus new species. 90. Brachinus microamericanus new species. 91. Brachinus capnicus new species. Map scale given here, used on all maps in Section 4. Triangles (▲) indicate state locality only.

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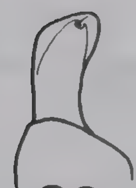

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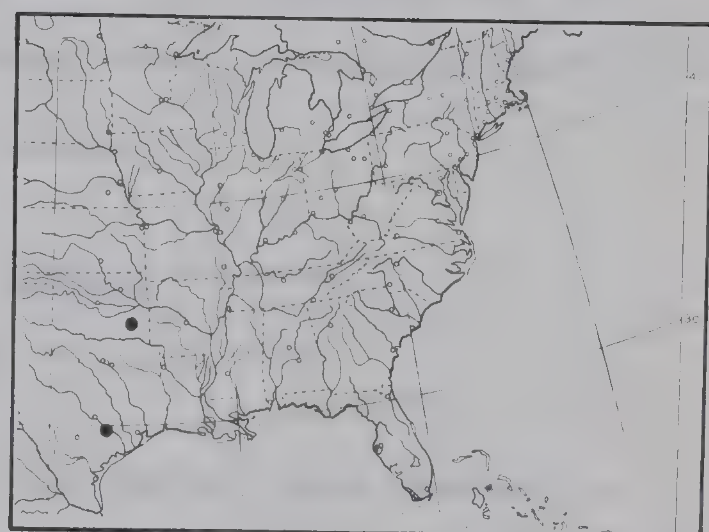

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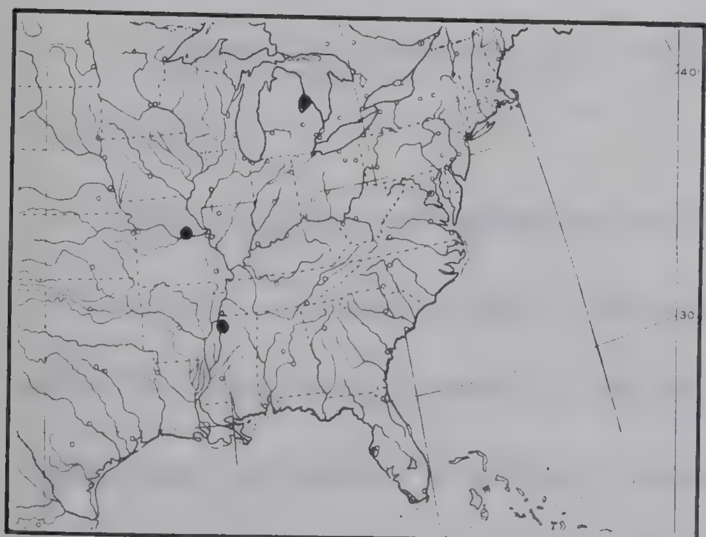

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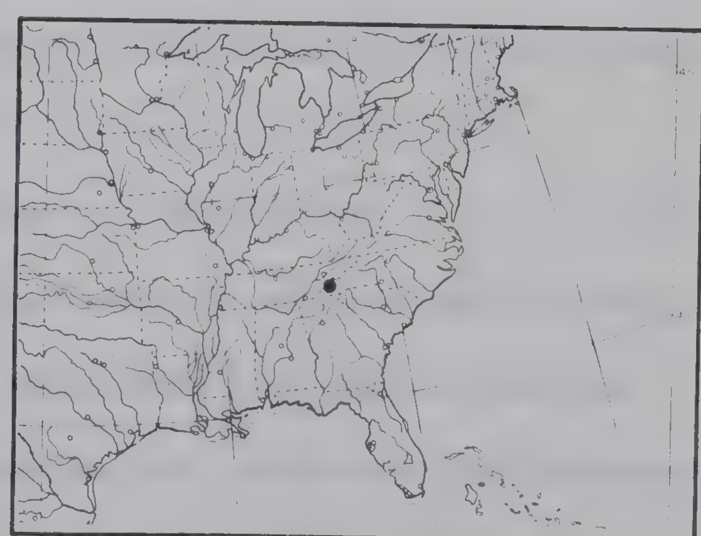

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MAP SCALE

0 1000 MILES

0 1400 KILOMETERS

LAMBERT AZIMUTHAL EQUAL-AREA PROJECTION

4.52 The texanus group

The members of this group are characterized as follows: virga of endophallus extensively pigmented and oriented horizontally on the internal sac; antennal articles robust; stylus of the female ovipositor very narrow and acute; elytral pubescence appearing in rows between costae. Three species, B. texanus Chaudoir, B. rhytiderus Chaudoir, and B. elongatulus Chaudoir, are included here, but certain South American species also belong to this group.

4.5201 Brachinus texanus Chaudoir
(Figs. 93, 95, 96, 97, 107, 108)

Brachinus texanus Chaudoir, 1868:299. Lectotype, here selected, a male, MHNP, labelled "Tejas" and "Ex Museo Chaudoir." Type locality.—Texas, as originally given by Chaudoir.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 7.3 to 9.9 mm.

Color. Mesepisterna, metepisterna, usually metasternum at sides, sides of abdominal sterna, sternum 6, and abdominal terga infuscated, sometimes antennal articles 3 and 4 infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra slate-grey with greenish luster.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrow and surface of pronotum rugose and punctate, punctures moderately impressed.

Head. Frontal furrows moderately impressed. Antennal scape robust, widest at middle. Ligula with sclerotized center area

ellipsoid-convex with two paramedian setae and two apical setae. Mentum and submentum usually with accessory setae.

Prothorax. Pronotum (fig. 93), convex, flattened along center line, sides slightly reflexed. Proepipleura glabrous. Proepisterna with setae anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior surface strigose.

Pterothorax. Elytra elongate, narrow, moderately costate. Humeral angles square. Costae smooth, glabrous, depressions pubescent. Hind wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 95, 96, 97). Median lobe with plane of shaft rotated slightly from plane of basal bend. Basal bend short. Shaft nearly straight, swollen slightly at middle, apex acute and narrow. Ligule broad moderately long, truncate. Virga (figs. 95, 96). Female (fig. 107). Stylus narrow, long and acute at apex.

Variation.—Intrapopulational variation occurs in the following characteristics: shape of the pronotum; total length; extent of infuscation on the venter; and intensity of infuscation of the antennal articles 3 and 4. In all specimens the sides of the abdomen and the metepisterna are infuscated. Usually, sternum 6 is more darkly infuscated than the other abdominal sterna, but sometimes the latter are also quite dark, except at the very middle. In the very darkest specimens only the middle of sternum 2 between the hind coxae is ferrugineous. In this case the sides of the metasternum are also infuscated.

Flight.—These beetles have been repeatedly collected at lights in Texas.

Etymology.—The latinized form of Texas, the place where the types were collected.

Life history.—Members of this species have been collected from March to November. I have seen a teneral adult collected in July, at Austin, Texas. Overwintering probably takes place in the adult stage, as in *B. pallidus*.

Distribution.—(Fig. 108). The range of this species extends from New York to Alberta, Canada, south to southern Texas. The northern records from New York, Virginia, Michigan, Minnesota, and Alberta seem to be disjunctions from the main range. I have seen 1,549 specimens from the following localities:

CANADA

ALBERTA: Chin Coulee (Oldman River) UASM.

UNITED STATES

ALABAMA: Dallas County (Marion Junction) CNHM; Sumter County (Livingston) AMNH; Tuscaloosa County (Tuscaloosa) UASM; County unknown (Dilchamps) CAS. ARKANSAS: Chicot County (Lake Village) CUNY; Faulkner County (Conway) UAFA; Hempstead County UAFA, (Hope) CAS, MCZ, UMAH; Hot Springs County (Malvern) JSch; Pulaski County UAFA, (8.0 miles north of Camp Robinson) CNHM, (Little Rock) MCZ; Sebastian County (Fort Chaffee) RCGr; Washington County ISNH, (Cove Creek Valley) UAFA, (Fayettville) UAFA. FLORIDA: Pinellas County (Dunedin) TAMU. KANSAS: Douglas County (Lawrence) PUM; Montgomery County (Independence) AUAA; Rooks County KSU. LOUISIANA: Caddo-Bossier Parishes (Bossier City) CNC; De Soto Parish (Mansfield) USNM; East Baton Rouge Parish (Baton Rouge) UAFA; Franklin Parish (Chance) UAFA, (Chase) UAFA; Jefferson Davis

Parish (Hathaway) UAFA; Madison Parish (Tallulah) MSUM; Natchitoches Parish (Vowells Mill) USNM; Ouachita Parish (Calhoun) UAFA; Vermilion Parish (Gueydan) USNM; Vernon Parish (Rosepine) UAFA; Parish unknown (Auston) UATA. MASSACHUSETTS: Plymouth County (Plymouth) CNHM. MICHIGAN: Allegan County (Allegan) CAS. MISSISSIPPI: Copiah County (Crystal Springs) MCZ; Hinds County (Jackson) TAMU, (Raymond) RCGr; Pike County (McComb) UWSW; County unknown (McCormick) UWSW. MISSOURI: Barry County (Monett) USNM; Pulaski County (Fort Leonard Wood) CAS; Saint Louis County (Saint Louis) CAS; Vernon County (Nevada) FDAG, UASM. NEBRASKA: Lancaster County (Lincoln) UNLN. OKLAHOMA: Canadian County (El Reno) CNHM; Choctaw County (Hugo) AMNH; Cleveland County (Norman) CAS, UONO; Custer County (Clinton) AMNH; Grandy County (Chickasha) OSUS; Grayson County (Juniper Point, Lake Texoma, 12.0 miles north of Whitesboro) RCGr; Latimer County OSUS; Lawton County (Fort Sill) ISUA; Logan County (Guthrie) CNHM; McClaine County UONO; Marshall County (Lake Texoma, Willis) RCGr, (Lake Texoma, 2.0 miles east of Willis) RCGr, UCD, (Madill) RCGr; Muskogee County (Muskogee) USUL; Nowata County (13.0 miles west of Vinita) RFre; Oklahoma County (Oklahoma City) CAS; Payne County (Stillwater) OSUS; Tulsa County (Tulsa) CAS, DHKa. TENNESSEE: Davidson County (Nashville) TCBa; Lincoln County (Fayetteville) GRNo; Madison County (Jackson) CNC; Putnam County (Cookville) TCBa. TEXAS: Baylor County (8.0 miles south Seymour) CNHM; Bell County (Temple) CNHM; Bexar County (San Antonio) CAS, CEWh, MCZ, OSUS, TAMU, TLEr, UCR; Blanco County (Cypress Mill) USMN, (2.0 miles south of Round Mountain) UASM; Brazos County (College Station) CAS, TAMU, (Texas Experiment Station) TAMU; Cameron County (Brownsville) USMN; Cass County (Linden) CNC; Cherokee County

(Alto) JSch; Comal County (New Braunfels) TCBa, UASM, USNM; Cooke County (Gainesville) USNM; Dallas County (Dallas) CAS, CUNY, INSH, MCZ, PSUU, UASM, UMAH, UMSP, USNM; Denton County CAS; Dimmit County (Texas Experiment Station) TAMU; Eastland County UMSP; El Paso County (El Paso) CMPP; Ennis County (Ennis) AMNH; Erath County (Dublin) ISUA; Grayson County (Sherman) AMNH; Hunt County (Wolfe City) CUNY; Jefferson County (Port Arthur) AMNH, (Sabine Pass) WSUP; Jones County (Stanford) AMNH; Karnes County (Gillett) CUNY; Kerr County (Kerrville) CNC; Kleberg County (Kingsville) CUNY, ISUA; Leon County CAS; Liberty County (Liberty) UWSW; McLennan County (China Spring) CNHM; Montague County (2.5 miles southwest of Forestburg) CNHM; Montgomery County (Willis) OSUC; Oldham County (Matador Ranch) UWSW; Palo Pinto County (Mineral Wells) TCBa; Panola County (Carthage) AMNH; Potter County (Amarillo) UWSW; Robertson County (Hearne) CAS; Scurry County (Snyder) TCBa; Stephens County (Breckenridge) TCBa; Tarrant County OSUS, UMAH, (Fort Worth) CUNY; Taylor County (Abilene) UATA; Travis County (Austin) CAS, FDAG, MCZ, OUCO, UASM, UWMW, WSUP, ZMLS; Val Verde County OUCO; Victoria County (Victoria) UASM, UMAH, USNM; Washington County (Brenham) USNM; Webb County (Laredo) UWSW; Williamson County (Elm Water Cave) TCBa; Zavalla County (Nueces) USNM; Counties unknown (Belfrage) MCZ, (Camp Barkely) OSUC, (Carancahua) USNM, (Fuller) USNM, (Virginia Point) USNM. VIRGINIA: (No locality given) ANSP. WISCONSIN: Iron County (Mercer) MCZ, UWMW.

4.5202 _Brachinus_ _rhytiderus_ Chaudoir

(Figs. 92, 99, 100, 101, 105, 110)

Brachynus _rhytiderus_ Chaudoir, 1876:76. Lectotype, here selected, a

male, MHNP, labelled "Mexique" and "Ex Museo Chaudoir," standing first in a series of seven specimens. Type locality.—Mexico, as originally given by Chaudoir, but herewith restricted to San Luis Potosi, Mexico.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Small to medium-sized beetles, 5.2 to 9.1 mm.

Color. Except for the constantly darkened terga, the infuscated areas of these beetles are ill-defined. Usually, the antennal articles 3 and 4 are darker than 1 and 2. The metepisterna and sides of the abdomen are usually quite dark, but the center of the abdominal sterna are slightly infuscated, making them darker than the color of the pronotum. Usually the tibiae are infuscated, but the degree varies with the specimens. Dorsal surface and epipleura of elytra slate-colored.

Microsculpture. As described for genus.

Macrosculpture. As in *texanus*.

Head. As in *texanus*, except mentum and submentum without accessory setae.

Prothorax. As in *texanus*. Pronotum (fig. 92).

Pterothorax. As in *texanus*, except pubescence usually very sparse in discal depressions.

Abdomen. As described for genus.

Genitalia. Male (figs. 99, 100, 101). Median lobe as in *texanus*, slightly more arcuate. Virga (figs. 99, 100). Female (fig. 105). Stylus elongate, narrow, apically acute, but not as sharp as in *texanus*.

Variation.—As in elongatulus. The intensity of infuscation seems to vary clinally with darker specimens on the Yucatan Peninsula, in the southern part of Mexico, and in Central America, while the paler individuals are in Texas.

Flight.—The flight of these beetles has been recorded at lights repeatedly in Mexico.

Etymology.—Greek, rhytido = wrinkle, deros = skin; referring to the costate elytra of these beetles.

Collecting notes.—G. E. Ball and D. R. Whitehead have collected these beetles from under litter in palm forests at the edge of a large grassy swamp in San Luis Potosi; at the margin of the Rio Tula, in Hidalgo; and near the edge of a small stream (in litter) in Queretaro. They also collected specimens in roadside litter (vegetation) near Comitan, Chiapas. In Nicaragua, these beetles have been collected repeatedly in cotton fields.

Life history.—Members of this species have been collected in all months of the year, except January and February. I have seen a teneral adult collected in September in the state of Chiapas, Mexico. Overwintering or aestivation probably takes place in the adult stage.

Distribution.—(Fig. 110). The known range of this species extends from Texas south along the eastern side of Mexico to the Canal Zone, Panama. I have seen 625 specimens from the following localities:

CENTRAL AMERICA

CANAL ZONE: (Barro Colorado) MCZ. COSTA RICA: (5.0 kilometers north of Cañas) GRNo; (La Carpentera) USNM; (San Jose) MCZ, TCBa; (San Pedro) GRNo; (Tres Rios) MCZ; (Turrialba) CAS; (Zent, Limón) MCZ. GUATEMALA: (Agua Caliente) MCZ; (Antigua) AMNH, MCZ; (Los Amates) MCZ; (Palin)

USNM; (Panzos) MCZ; (Tamahu) AMNH. NICARAGUA: (La Calera) USNM. HONDURAS: CUNY, (El Paraiso) UCD; (La Lima) DTRT; (Rancho Chiquito, Department of Comayagua) FDAG. PANAMA: (Rovira, Chiriqui) SJSC.

MEXICO

DURANGO: MCZ. CHIAPAS: (3.2 miles north of Arriaga) UASM; (15.6 miles west of Comitan) UASM; (32.5 miles east of Comitan) UASM; (El Rosario, northwest of Comitan) RTBe; (4.9 miles north of Frontera Comalapa) UASM; (7.7 miles north of Frontera Comalapa) UASM; (16.3 miles southwest of Las Cruces) UASM; (11.6 miles north of Ocozocuautla) UASM; (Palenque ruins) UASM; (20.0 miles south of Tuxtla Gutierrez) UCD. HIDALGO: (Jacala) CNC. MICHOACAN: (Sahuayo) WSUP. NUEVO LEON: (Huasteca Cañon, near Monterrey) CNC; (14.8 miles west of Linares) UASM; (Mesa de Chipinque, near Monterrey) AMNH; (Montemorelos) CAS; (Monterrey) CNC; (5.0 miles south of Monterrey) CNC; (6.0 miles south of Monterrey) CNC, FDAG; (Rio Elizondo, near Monterrey) MCZ; (Santa Rosa Cañon, 14.8 miles west of Linares) UASM. OAXACA: (La Ventosa) UCR; (50.0 miles north of La Ventosa) ISUA; (Oaxaca) BMNH; (Puente Zanatepec, near Zanatepec) UASM; (Rio Malatengo, 11.1 miles north of Matias Romero) UASM; (Rio Niltepec, 18.4 miles west of Zanatepec) UASM; (Tapanatepec) UASM; (3.0 miles northwest of Tapanatepec) ISUA; (17.0 miles northwest of Zanatepec) ISUA. PUEBLA: (Villa Juarez) JHen. QUERETARO: (Landa de Matamoros) UASM. SAN LUIS POTOSI: (Ciudad de Valles) WSUP; (5.0 miles northeast of Ciudad del Maiz) CNC; (El Naranjo) OSUC; (1.8 miles north of El Naranjo) UASM; (3.6 miles west of El Naranjo) UASM; (El Salto Falls) FDAG; (2.7 miles west of Santa Catarina) UASM; (Tamazunchale) AMNH, DRWh, MCZ. TAMAULIPAS: (2.0 miles west of Antiguo Morelos) DRWh; (14.0 miles

west of Antiguo Morelos) UASM; (Ciudad Mante) CNC; (47.0 kilometers south of Ciudad Victoria) MCZ; (Gomez Farias and vicinity) AMNH, CUNY; (73.1 miles north of Manuel) UASM; (101.1 miles north of Manuel) UASM; (20.0 miles south of Victoria) TCBa, UCD; (20.6 miles east of Villa de Casas) UASM; (23.1 miles east of Villa de Casas) UASM. VERACRUZ: (5.0 miles northwest of Acayucan) UCD; (30.0 miles south of Acayucan) UCD; (Cordoba) AMNH, CAS; (10.0 miles east of Cordoba) GRNo; (Cotaxtla Experiment Station) CAS; (Coyame, Lake Catemaco) DRWh; (Fortin de las Flores) CUNY, DRWh, UASM; (20.0 miles northwest of Huatusco) FDAG; (Jalapa) AMNH, ANSP, BMNH, CAS, MCZ; (3.0 miles northwest of Jalapa) GRNo; (Los Tuxtlas Range) TAMU; (Orizaba) MCZ; (2.5 miles west of Sontecomapan) UASM; (Tinajas) UCD; (Veracruz) UASM. YUCATAN: (Chuminopolis) AMNH; (Merida) AMNH; (Piste) SJSC; (Ruinas de Kabah) UASM.

UNITED STATES

TEXAS: Bee County (Beeville) USNM; Cameron County CAS, MCZ, USNM, UWMW, (Brownsville) USNM, WHTy; Comal County (New Braunfels) UASM, USNM; Kendall County (5-10.0 miles north of Boerne) UASM; Kleberg County (Kingsville) CUNY; Travis County (Austin) CAS, WSUP; Victoria County (Victoria) USNM; County unknown (Belfrage) USNM.

4.5203 Brachinus elongatulus Chaudoir
(Figs. 94, 98, 102, 103, 104, 106, 109)

Brachynus elongatulus Chaudoir, 1876:75. Lectotype, here selected, a female, MHNP, labelled "40" and "Ex Museo Chaudoir," standing first in a series of eleven specimens in front of label "B. elongatulus Chaudoir." Type locality.—Orizaba, Mexico, as

originally given by Chaudoir.

Brachynus brevior Chaudoir, 1876:75. Lectotype, here selected, a female, MHNP, labelled "Mexique" and "Ex Museo Chaudoir."

Type locality.—Oaxaca, Mexico, as originally given by Chaudoir.

Blackwelder, 1944:71.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Small to medium-sized beetles, 4.8 to 10.6 mm.

Color. Antennal articles 3 and 4, metepisterna, and sides of abdominal sterna infuscated. Tibiae, and tarsi sometimes infuscated, otherwise beetles ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. As in texanus, except punctures more deeply impressed.

Head. As in texanus.

Prothorax. As in texanus. Pronotum (fig. 94).

Pterothorax. As in texanus, except elytra more elongate and more strongly costate.

Abdomen. As described for genus.

Genitalia. Male (figs. 102, 103, 104). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend short. Shaft and apex as in texanus. Ligule short, broad, truncate. Virga (figs. 102, 103). Female (fig. 106). Stylus narrow, moderately long, rounded apically.

Variation.—Intrapopulational variation occurs in the shape of the pronotum and in the total size, and the tibiae and tarsi may or

may not be infuscated. Rarely the metepisterna are ferrugineous.

Flight.—These beetles have been collected repeatedly at lights throughout the range of the species.

Etymology.—Latin, elongatus = prolonged; referring to the elongate elytra of these beetles.

Collecting notes.—My wife and I collected these beetles from beneath stones along streams in many localities. At Herb Martyr Dam near Portal, Arizona, these beetles were beneath stones piled on top of other stones which were embedded in loamy soil. The stones were covered with oak leaf litter and were next to flowing water.

Life history.—Members of this species have been collected during all months of the year. I have seen teneral adults collected in August from Arizona; in July from Michoacan; in November from Jalisco; and in October from Acapulco. Overwintering probably takes place in the adult stage.

Distribution.—(Fig. 109). The range of this species extends from Arizona south to Oaxaca and into Baja California. Two specimens have been recorded from the Pacific Coast, one from Oregon and one from California. I have seen 3,810 specimens from the following localities:

MEXICO

AGUASCALIENTES: (Aguascalientes) AMNH, JHen; (4.0 miles southwest of Aguascalientes) AMNH; (11.0 miles west of Aguascalientes) UASM; (Mal Paso, 7.0 miles east of Calvillo) AMNH; (15.0 miles west of Pabelon) UMAH. BAJA CALIFORNIA: (Big Cañon, Sierra Laguna) CAS; (La Laguna) GRNo; (Las Animas Cañon Ensenada) SDSNH; (Las Animas, Sierra Laguna) CAS; (12.0 miles northwest of San Bartolo) CAS. CHIHUAHUA: (Buena

Vista) AMNH; (Carta Blanca, 16.0 miles west of Matachic) AMNH; (Catarinas) AMNH; (Chihuahua) CNC; (25.0 miles northwest of Chihuahua) CNC; (10.0 miles east of Cuaohtemoc) ISUA; (32.0 miles south of Hidalgo de Parral) CAS; (1.0 mile east of La Sauceda) AMNH; (8.0 miles west of Matachic) AMNH; (Mesa del Huracan, 108° 15′ 30° 4′) CNC; (23.0 miles south of Miñaca) UASM; (Ojo Laguna) AMNH; (Primavera) AMNH; (San Jose Babicora) AMNH; (San Rafael) AMNH; (Santa Barbara) AMNH; (Santa Clara Cañon, 5.0 miles west of Parrita) AMNH; (Santa Clara, Namiquipa District) AMNH; (Sombreretillo) CAS. DISTRITO FEDERAL: (Creek at Lomas de Chapultepec) MCZ; (Mexico City) JHen, MCZ, WSUP; (Mixcoac) JHen; (Peñon Viejo) MCZ; (Tacubaya) JHen; (Villa Guadalupe) JHen. DURANGO: (Arroyo El Sauz, 33.0 miles north of Durango) MCZ; (Durango City) AMNH, ANSP, CUNY, MCZ, WSUP; (5.0 miles west of Durango) CNC; (10.0 miles west of Durango) CNC, ISUA; (15.0 miles west of Durango) CNC; (20.0 miles west of Durango) CNC; (23.0 miles south of Durango) CNC; (25.0 miles west of Durango) CNC; (27.5 miles west of Durango) UASM; (18.0 miles east of El Salto) AMNH; (Las Puentes) AMNH; (Nombre de Dios) AMNH; (Rio Chico, 15.7 miles west of Durango) UASM; (Rio Florido, near Las Nieves) UASM. GUANAJUATO: (2.0 miles north of Irapuato) CNC; (Rio Guanajuato, 9.8 miles south Silao) UASM; (San Miguel Allende) AMNH. GUERRERO: (Acapulco) JHen, MCZ; (Apipilulco) MCZ; (Cacahuamilpa) JHen; (Chilpancingo) CNC; (8.4 miles west of Chilpancingo) UASM; (Rio Mezcala, 23.7 miles north of Zumpango) UASM; (Rio Papagayo, 41.0 miles north of Acapulco) UASM; (Xilitla) AMNH; (9.0 miles north of Zumpango) ISUA; (30.8 miles north of Zumpango del Rio) UASM. HIDALGO: (Guadalupe) MCZ; (Huichapan) LACM; (Rio Tula, near Tasquillo) UASM; (San Miguel) MCZ. JALISCO-NAYARIT: (No locality

given) AMNH. JALISCO: (Ajijic) AMNH, JHen, UATA; (23.2 miles south of Autlan) UASM; (Atenquique) CAS; (3.0 miles north of Barra de Navidad, Bahia de Coastecomate) UATA; (Barranquillas) UCR; (0.4 miles west of Cocula) UASM; (Cruzero de Malpaso, 17.7 miles northwest of Los Volcanes) UASM; (Guadalajara) AMNH, CUNY, MCZ, RTBe; (61.0 kilometers southwest of Guadalajara) UATA; (Huascato) USNM; (10.0 miles west of Jiquilpan) CAS; (15-20.0 miles west of Jiquilpan) CAS; (8.5 miles north of Juchitlan) UASM; (13.0 miles southeast of Lagos de Moreno) UASM; (17.9 miles west of Magdalena) UASM; (Mountains west of Tecalitlan) UATA; (Ocotlan) CAS; (Puente Caquixtle, 9.7 miles east of Encarnacion de Diaz) UASM; (Puente La Garita, near La Garita) UASM; (Puerto Vallarta) CNC; (Rio Grande de Santiago, 12.5 miles west of Ixtlahuacan del Rio) UASM; (4.0 miles south of Talpa de Allende) UASM; (6.5 miles south of Talpa de Allende) UASM; (21.0 miles northeast of Tepatitlan) CAS; (Tuxpan) MCZ; (Savula) USNM; (Valle de Guadaloupe) CAS. MEXICO: (Lago Zumpango, near San Juan Zitlalepec) UASM; (Los Remedios) JHen; (Serros Guadalupe) JHen; (Temascaltepec, Tejupilco) CAS. MICHOACAN: (Comanja) CAS; (1.3 miles east of Comanja) UASM; (5.0 kilometers west of Ciudad Hidalgo) MCZ; (11.0 miles west of Hidalgo) UCD; (Huajumbaro) UASM; (10.0 miles west of Jiquilpan) DRWh; (10.6 miles south of La Huerta) UASM; (Morelia) AMNH, UASM; (9.5 miles west of Morelia) UASM; (25.0 kilometers east of Morelia) RTBe; (3.0 miles west of Quiroga) AMNH; (6.0 kilometers east of Quiroga) UASM; (Tuxpan) CAS, RTBe; (near Tzintzuntzan) UASM; (8.1 miles east of Vallamar) UASM; (10.0 miles east of Zamora) GRNo; (14.0 miles northwest of Zitacuaro) UCD; (50.0 miles west of Zitacuaro) MCZ. MORELOS: (Cañon de Lobos,

9.1 miles east of Cuernavaca) UASM; (Cuautla) JHen; (Cuernavaca) CAS, CNC, CUNY, MCZ, RCGr, TMBH; (3.6 miles east of Cuernavaca) UASM; (5.4 miles east of Cuernavaca) UASM; (Progreso) CUNY; (Tejalpa) DRWh, FDAG; (Tepoztlan) RCGr; (Xochitepec) JHen; (Yautepec) UCD. NAYARIT: (5.1 miles north of Chapalilla) UASM; (20.3 miles west of Compostela) GRNo; (Ixtlan del Rio) CAS; (San Blas) UCD; (8.7 miles east of San Blas) GRNo; (13.8 miles east of San Blas) UASM; (Tepic) AMNH, UATA; (19.0 miles southeast of Tepic) CAS; (24.0 miles southeast of Tepic) CAS. OAXACA: (25.0 miles south of Mitla) ISUA; (Oaxaca) UMAH; (Rio Atoyac, near Juchatengo) UASM; (9.3 miles north of Sola de Vega) UASM; (72.5 miles south of Valle Nacional, Rio Grande) UASM. PUEBLA: (9.0 miles north of Amatitlan) CAS; (5.0 miles south of Izucar de Matamoros) UCD; (near Petlalcingo) UASM; (3.0 miles northwest of Petlalcingo) UCD; (Puente Tepexco, near Tepexco) UASM; (Tehuacan) CAS, JHen; (near Tehuitzingo) UASM; (near Tepexco) UASM. QUERETARO: (6.0 miles east of Celaya) UASM; (near Palmillas) UASM; (6.4 miles east of Pinal de Amoles) UASM; (Queretaro) UASM; (3.0 miles west of Queretaro) AMNH. SAN LUIS POTOSI: (25.0 kilometers east of Santa Domingo) MCZ. SINALOA: (Camino Real de Piaxtla) AMNH; (3.4 miles west, 5.0 miles south of Culiacan) GRNo; (3.0 miles east of Culiacancito) GRNo; (2.1 miles northeast of El Fuerte) GRNo; (Mazatlan) AMNH, MCZ, UCR; (5.0 miles north of Mazatlan) GRNo; (10.0 miles north of Mazatlan) GRNo; (Rio Baluarte, near Rosario) UASM; (Quiroroba, Alamosa) CAS; (Rio Panuco 11.2 miles northeast of Concordia) UASM; (Rio Piaxtla, 1.0 miles east of Route 15) UASM; (Rosario) CAS; (20.0 miles east of Villa Union) UCR; (21.0 miles east of Villa Union) CNC; (27.0 miles east of Villa Union) CNC;

(33.0 miles east of Villa Union) CNC; (Venedio) CAS; (Zenzontle, Culiacan) AMNH. SONORA: (65.0 miles southeast of Agua Prieta) ISUA; (Alamos) CAS; (4.0 miles west of Alamos) GRNo; (5.0 miles west of Alamos) UATA; (7.2 miles southeast of Alamos) GRNo; (Caramechi, Rio Mayo) CAS; (8.0 miles east of Imuris) CAS; (San Bernardo, Rio Mayo) CAS; (Yecora) CNC. TAMAULIPAS: (Ciudad Victoria) CNHM; (Sotano de La Joya de Salas) TCBa. TLAXCALA: (21.0 miles west of Apizaco) CNC. ZACATECAS: (29.0 miles northwest of Fresnillo) UASM; (Presa Choquen) JHen; (Rio Juchipila, 0.9 miles north of Jalpa) UASM; (1.3 miles southeast Sain Alto) UASM.

UNITED STATES

ARIZONA: Apache County (White Mountains) CAS; Cochise County (Benson) CAS, UWSW, (Bisbee) CAS, (Canelo) UATA, (Canelo, Pyeatt's Ranch) CUNY, (Cave Creek) AMNH, (Cave Creek Canyon) CNHM, (Cave Creek, South Fork) GRNo, (Chiricahua Mountains) CAS, OUCO, UASM, USNM, (Chiricahua Mountains, Cave Creek Ranch) TCBa, UASM, (Chiricahua Mountains, 15.0 miles west of Portal) UCD, (Chiricahua Mountains, Redrock Canyon) CAS, (Chiricahua Mountains, Rustlers Park) CNC, (Chiricahua Mountains, Silver Creek wash, 3.3 miles west by northwest of Portal) CUNY, (Chiricahua Mountains, Texas Canyon) CAS, (Chiricahua National Monument) AMNH, CAS, (Cochise Stronghold) TLEr, UATA, (Douglas) CAS, CNHM, (10.0 miles west of Douglas) TLEr, (Guadalupe Canyon, 32.0 miles east of Douglas) CUNY, UCR, (Herb Martyr Dam, South West Research Station) TLEr, (Huachuca Mountains) AMNH, CAS, TAMU, UATA, USNM, (Huachuca Mountains, Carr Canyon) AMNH, CAS, TLEr, (Huachuca Mountains, Fort Huachuca) LACM, (Huachuca Mountains, Garden Canyon) CAS, USNM, (Huachuca Mountains, Huachuca Canyon) LACM,

(Huachuca Mountains, Miller Canyon) CAS, MCZ, OUCO, UCR, (Huachuca Mountains, Sunnyside Canyon) CAS, LACM, (Palmerlee) ANSP, CAS, UMAH, (Paradise) UASM, (Chiricahua Mountains, Pinery Creek) CNHM, (Portal) AMNH, TLEr, RCGr, SJSC, WHTy, WSUP, UCR, (Ramsey Canyon Mountains) CAS, SJSC, UATA, UMNH, USNM, (Chiricahua Mountains, Rucker Lake) UASM, (San Pedro near Palominas) UASM, (San Pedro River east of Sierra Vista) UATA, (South Fork Forest Camp, 4.5 miles west of Portal) CAS, (South West Research Station, Portal) AMNH, CNC, CUNY, FDAG, OSUC, SJSC, TLEr, UATA, UCD, UCR, UIMI, (Wood Canyon, Bisbee) UATA; Gila County (Globe) KSU, UCD, (base of Pinal Mountains) CAS, UCD, (Roosevelt Lake) CNC, (Winkelman) UATA; Graham County (Arivaipa) CAS, (Aravaipa Creek, between Klondyke and Aravaipa) DRWh, (Galiuro Mountains, Powers' Garden) UASM, (Galiuro Mountains, Reservoir, east slope) UASM, (Graham Mountains, Shennon Camp) GRNo; Navajo County (8-15.0 miles northeast of Whiteriver) AMNH; Pima County (Baboquivari Mountains) CAS, CUNY, LACM, (Baboquivari Mountains, Browns Canyon) AMNH, CAS, UATA, (Baboquivari Mountains, Schalffer Canyon) ANSP, (BaboquivariMountains, Sabino Canyon Elkhorn Ranch) CAS, (East slope of Coyote Mountains, 0.5 miles north of Mendoza Canyon) UATA, (10.0 miles east of Continental) UATA, (4.0 miles south of Mountain View) CAS, (Sahuarita) MCZ, (Saint Xavier Mountains, Tucson) CAS, (Santa Catalina Mountains) CAS, UATA, USNM, (Santa Catalina Mountains, Mount Lemmon, Bear Canyon) CAS, CUNY, UATA, (Santa Catalina Mountains, Peppersauce Canyon) CAS, UASM, UATA, (Santa Catalina Mountains, Molino Basin) CUNY, TLEr, (Santa Rita Mountains) CAS, UATA, UMSP, USNM, (Santa Rita Mountains, Gardner Canyon) OSUC, (Tanque Verde) UATA, (Tucson) CAS, MCZ, UASM, UATA, UIMI, UMSP, USNM, (8.0 miles north

of Vail) UATA, Pinal County (Oracle) USNM, (14.0 miles east of Oracle) CAS, Santa Cruz County OSUC, (Calabasas Canyon, east Tumacacori Mountains) UASM, (Canille) AMNH, UATA, (Luis Springs, San Pedro River) UASM, (Nogales) CAS, CNHM, LACM, MCZ, UCD, USNM, ZMLS, (3.0 miles north of Nogales) LACM, (10.0 miles west of Nogales) UCD, (15.0 miles northwest of Nogales) UCD, (Pajaritos Mountains, Yanks Spring, 4.0 miles southeast of Ruby) AMNH, CAS, (Patagonia) CAS, CMPP, CNHM, CUNY, UATA, UCD, (Peña Blanca) CNC, CUNY, UASM, UATA, (Santa Rita Mountains, Madera Canyon) AMNH, ANSP, CAS, CUNY, GRNo, LACM, SJSC, RCGr, UASM, UATA, UCD, UWSW, WHTy, (Sonoita) WHTy, (Sonoita River, Patagonia) AMNH, (4.0 miles west of Sombrero Butte, Cherry Creek) USNM, (Tumacacori Mountains, Sycamore Canyon) CUNY, (Tumacacori Mountains, Sycamore Canyon, near Ruby) CUNY, UATA, (2.0 miles west of Washington Camp) UATA; Maricopa County (Gillespie's Dam) CAS; Yavapai County (Mayer) GRNo, (Prescott) CAS, Yuma County (15.0 miles east of Yuma) CNHM; Counties unknown (Florida) UATA, (Reef) MCZ, (near San Fernando) USNM, (Santa Cruz River) UATA, (Tortolita Mountains) CAS, (Wake Field Mine) PUM. CALIFORNIA: CMPP, ISNH, TMBH; Santa Cruz County (Amado) UMSP. OREGON: Lane County (Siltcoos Lake) CAS. NEW MEXICO: Catron County (Mogollon Mountains, Big Dry Creek) CAS, (Mogollon Mountains, Willow Creek) TLEr; Grant County (Silver City) MCZ; Hidalgo County (Guadalupe Canyon) GRNo, (Rodeo) UCR, (12.0 miles southeast of Rodeo, Post Office Canyon) SJSC. TEXAS: Jeff Davis County (Limpia Canyon) TLEr.

Figs. 92-94. Pronotum, right half, dorsal aspect. 92. Brachinus rhytiderus Chaudoir, Chuminopolis, Yucatan, Mexico. 93. Brachinus texanus Chaudoir, Mineral Wells, Texas. 94. Brachinus elongatulus Chaudoir, South West Research Station, Arizona. Figs. 95-97, 99-104. Male genitalia. 95. Brachinus texanus Chaudoir, Raymond, Mississippi, ventral aspect. 96. Lateral aspect of same. 97. Dorsal aspect of same. 99. Brachinus rhytiderus Chaudoir, 1.8 miles north of El Naranjo, San Luis Potosi, Mexico, ventral aspect. 100. Lateral aspect of same. 101. Dorsal aspect of same. 102. Brachinus elongatulus Chaudoir, Madera Canyon, Arizona, ventral aspect. 103. Lateral aspect of same. 104. Dorsal aspect of same. Fig. 98. Right elytron, dorsal aspect of humeral angle, Brachinus elongatulus Chaudoir, South West Research Station, Arizona. Accompanying scale lines equal 1.0 mm.

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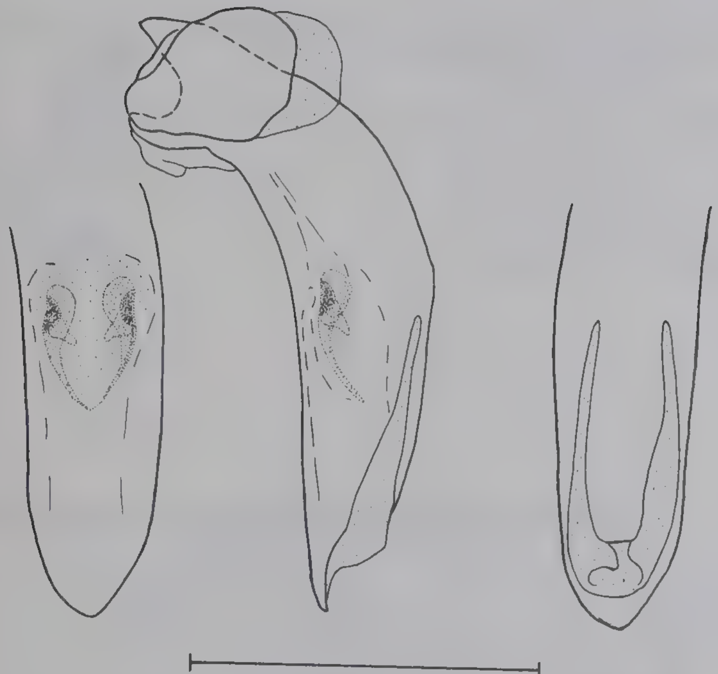
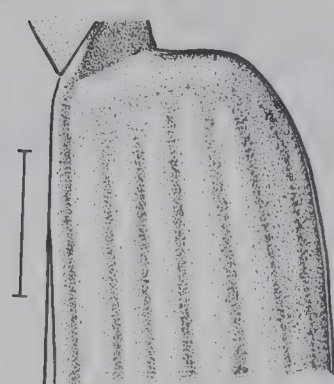


95 96 97



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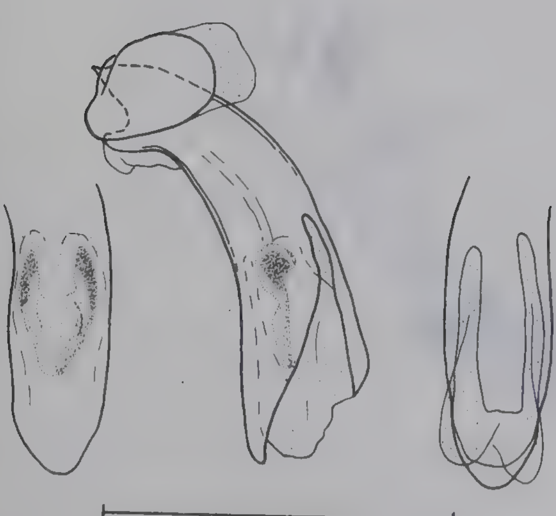

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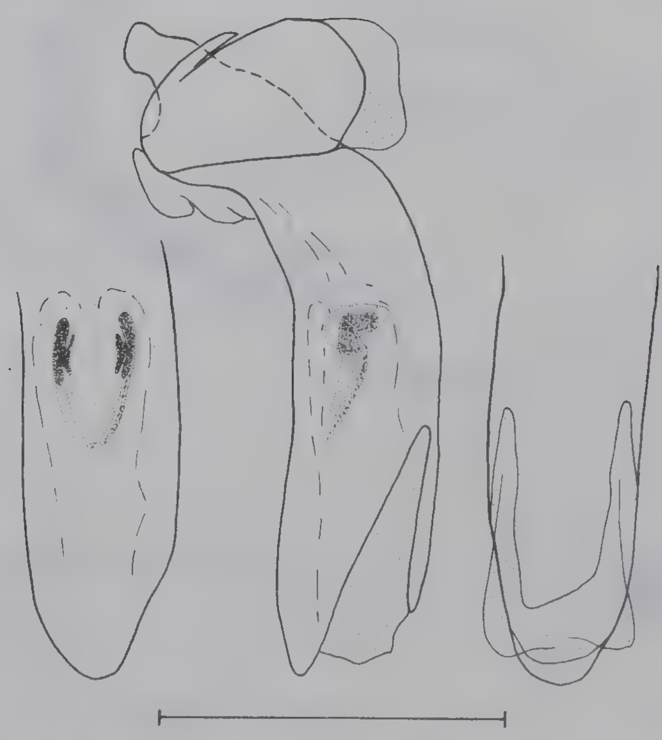

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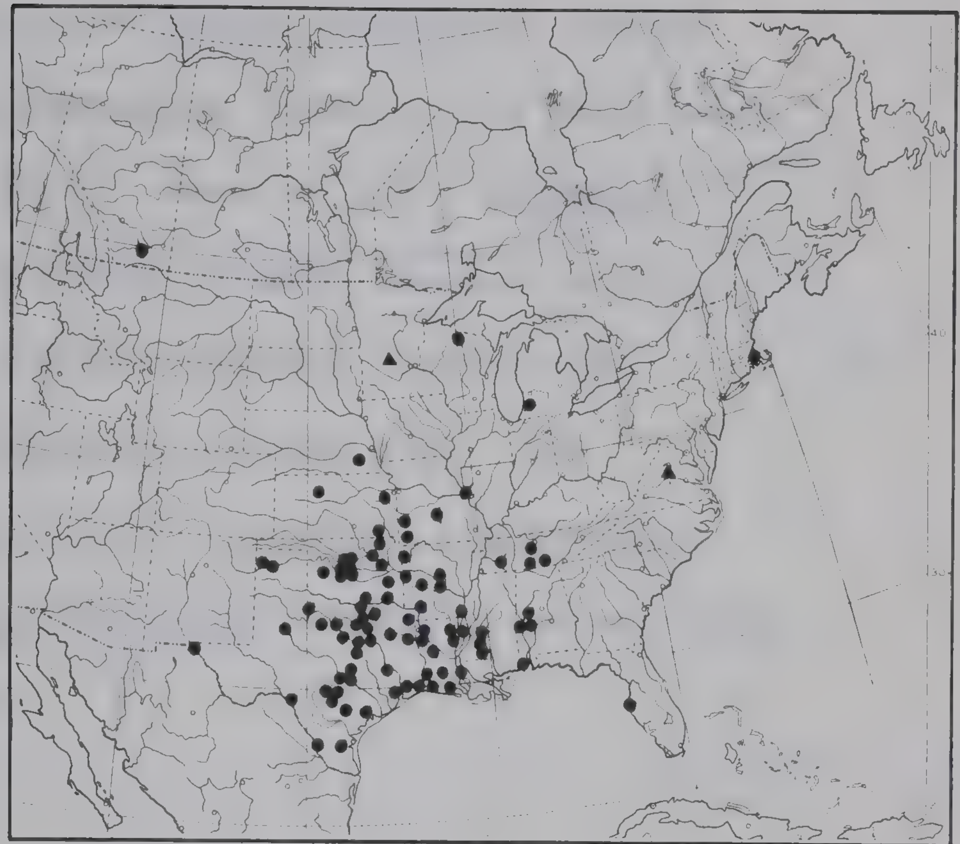
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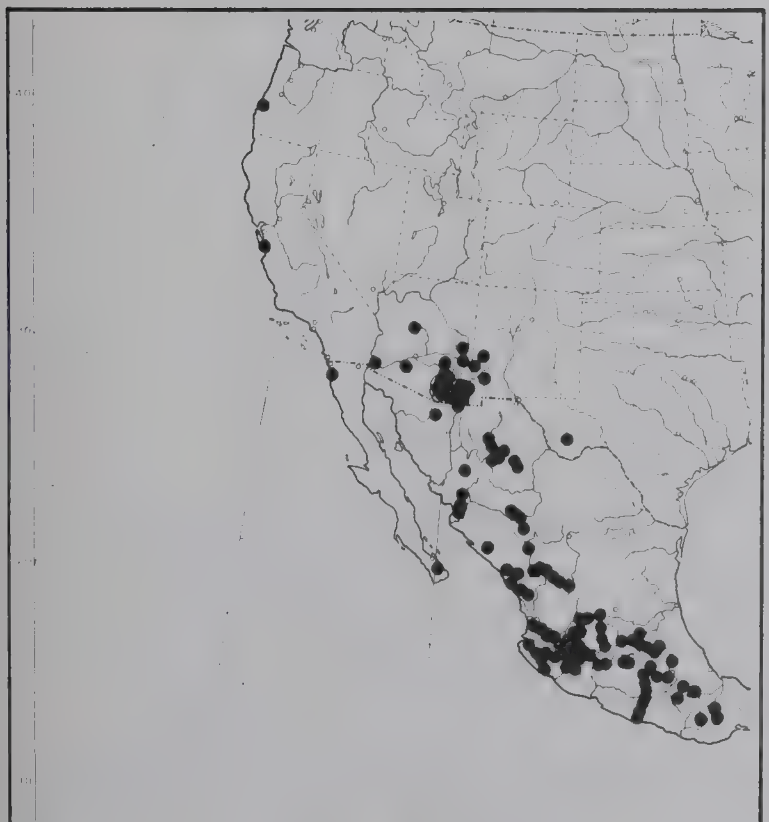
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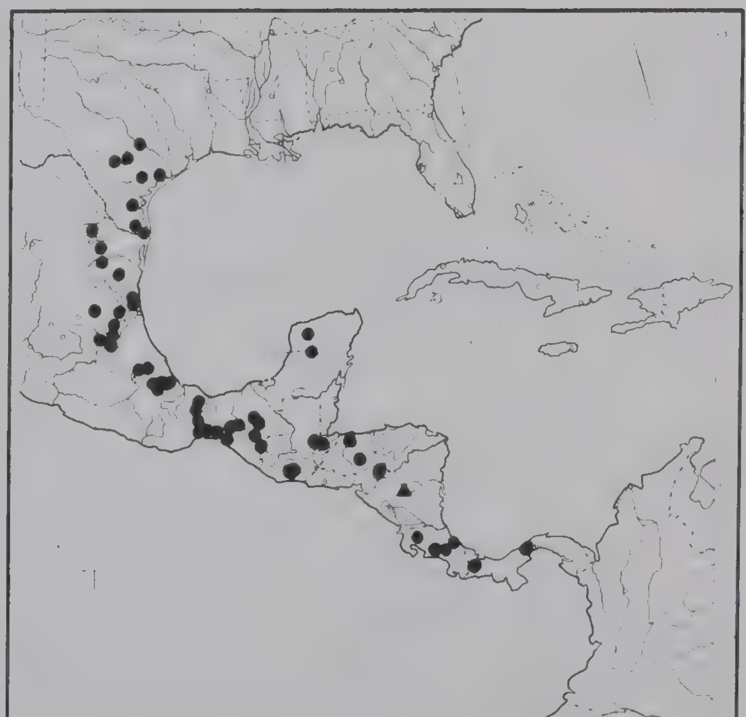
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Figs. 105-107. Right stylus of female ovipositor, ventral aspect. 105. Brachinus rhytiderus Chaudoir, 1.8 miles north of El Naranjo, San Luis Potosi, Mexico. 106. Brachinus elongatulus Chaudoir, South West Research Station, Arizona. 107. Brachinus texanus Chaudoir, Raymond, Mississippi.

Figs. 108-110. Geographical distribution maps. 108. Brachinus texanus Chaudoir. 109. Brachinus elongatulus Chaudoir. 110. Brachinus rhytiderus Chaudoir. Accompanying scale lines equal 1.0 mm.

4.53 The *sallei* group

The members of this group are characterized by their complete brown color, testaceous legs with infuscated knees, lateral pits of the mentum, and swollen median lobe. A single species, *B. sallei* Chaudoir is included here.

4.5301 *Brachinus sallei* Chaudoir

(Figs. 20, 112, 121, 122, 123, 128, 133)

Brachynus sallei Chaudoir, 1876:85. G. E. Ball could not locate Chaudoir's specimens in MHNP. Chaudoir wrote (1876:85) that other specimens were in Chevrolat's collection. E. Taylor informs me that these specimens are no longer in HMO. Therefore, I presume the type is lost.

Type locality.—Mexico, as originally given by Chaudoir, but herewith restricted to Tabasco, Mexico.

Notes.—Chaudoir compared *B. sallei* with Chevrolat's *B. spinipes*, in the original description of *B. sallei*. This name was never published by Chevrolat, and therefore not really in existence, but I add this note to stop possible confusion in the future.

Diagnostic combination.—See group characteristics and key.

Description.—Large-sized beetles, 12.1 to 15.1 mm.

Color. Dark brown, mouthparts and antennae somewhat paler. Legs testaceous with brown "knees" (femoral apices plus tibial bases). Dorsal surface of elytra dark brown, epipleura paler.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows rugose, sparsely punctate. Disc of pronotum finely rugose along center line. Punctures barely

impressed.

Head. Frontal furrows deeply impressed. Antennal scape quite robust, widest at middle. Ligula with sclerotized center area ellipsoid-convex with two apical setae. Mentum (fig. 20) with two lateral pits each surrounded by numerous setae. Submentum with numerous accessory setae.

Prothorax. Pronotum (fig. 112) convex, sides narrowly reflexed. Anterior and posterior margins with a few shallowly impressed setiferous punctures. Proepipleura glabrous. Proepisterna with a few small setae both anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior edge finely punctate.

Pterothorax. Elytra elongate, moderately costate. Humeral angle square. Pubescence confined to eighth depression, except near apex. Depressions punctate. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 121, 122, 123). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend short. Shaft swollen at basal third, flared and flattened at apical third. Ligule short, rounded apically. Virga (figs. 121, 122). Female (fig. 128). Stylus narrow, elongate, arcuate, acute at apex.

Variation.—Too few specimens are known to evaluate geographic variation, but the sixteen specimens I have seen are rather constant.

Flight.—J. G. Edwards collected a specimen at lights on Cozumel Island, Quintana Roo, Mexico.

Etymology.—Patronym for August Sallé, in whose collection Chaudoir first saw specimens of this species.

Collecting notes.—On the north shore of Lake Catemaco in Veracruz, Mexico, these beetles live in heavily shaded marshes about 10.0 meters from the lake edge. The predominant plant was a *Heliconia* species.

Life history.—Members of this species have been collected from December to April and in August. One teneral adult was collected in January in the state of Campeche, Mexico.

Distribution.—(Fig. 133). The known range of this species extends from southern San Luis Potosi to southern Chiapas and the Yucatan peninsula. The species also occurs on Isla Cozumel, off the coast of Quintana Roo. I have seen 16 specimens from the following localities:

MEXICO

CAMPECHE: (Edzna) UASM. CHIAPAS: (San Quintin, Chiquita Miramar) UASM. QUINTANA ROO TERRITORY: (Cozumel Island) SJSC. SAN LUIS POTOSI: (Valles) CPBo. TABASCO: (Macultepec) JHen; (Tierra Colorada de Itzmate) JHen. VERACRUZ: (Coyame, Lake Catemaco) UASM; (San Andres Tuxtla) UCR.

4.54 The *brunneus* group

The members of this group are characterized by the form of the virga, brown color of the body, and testaceous legs and infuscated knees. These beetles lack the lateral mental pits found in *B. sallei*. I have seen specimens of South American species that belong to this group. It is possible that when the South American fauna is better known, this group will have to be redefined. Two species, *B. brunneus* Castelnau, and *B. melanarthrus* Chaudoir are included here.

4.5401 Brachinus brunneus Castelnau

(Figs. 114, 124, 125, 126, 130, 134)

Brachinus brunneus Castelnau, 1834:59. Lectotype, here selected, a male, MHNP, unlabelled, but standing third in a series of seven in front of box labelled "brunneus Castelnau Antilles Mus. Berl." Chaudoir (1876:84) mentions that he received four specimens from Castelnau's type series. Type locality.—Cayenne, French Guiana as originally given by Castelnau.

Brachinus gilvipes Mannerheim, 1837:41. Lectotype, here selected, a female, MHNP, labelled "St. Thomas, Mannerheim" and standing fifth in a series of seven specimens in front of box labelled "brunneus Castelnau Antilles Mus. Berl." Type locality.—St. Thomas Island, Antilles as given on Mannerheim's label, and indicated by Chaudoir (1876:84). Chaudoir, 1876:84.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Small to medium-sized beetles, 7.0 to 9.0 mm.

Color. As in sallei.

Microsculpture. As described for genus.

Macrosculpture. As in sallei.

Head. As in sallei, except antennal scape not as robust, mentum without pits or accessory setae, submentum without accessory setae.

Prothorax. As in sallei. Pronotum (fig. 114).

Pterothorax. As in sallei, except elytral pubescence extending along depressions 6, 7, and 8, and costae barely elevated.

Abdomen. As described for genus.

Genitalia. Male (figs. 124, 125, 126). Median lobe with plane of shaft rotated 45° from plane of basal bend. Basal bend short. Apex of shaft rounded. Ligule short, narrow, rounded apically. Virga (figs. 124, 125). Female (fig. 130). Stylus narrow, acute at apex.

Variation.—Besides the intrapopulational variation in the shape of the pronotum and the total size, these beetles exhibit color differences of the third and fourth antennal articles. The range is from testaceous with infuscated bases to completely infuscated, and occurs within single population samples.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Medieval Latin, brunneus = brown; referring to the color of these beetles.

Life history.—Members of this species have been collected in October, January, March, and May. No teneral adults have been seen.

Distribution.—(Fig. 134). The known range of this species extends from French Guiana to Puerto Rico and Hispaniola (Haiti). I have seen 45 specimens from the following localities:

GREATER ANTILLES

HAITI: (Etang Lachaux, southwest Peninsula) MCZ. PUERTO RICO: (Humacao) CUNY, MCZ; (Lagona Guanicá) MCZ; (Mayaguez) CUNY; (Saint Thomas Island) MHNP; (Toa-Baja) CUNY, MCZ.

4.5402 Brachinus melanarthrus Chaudoir

(Figs. 19, 111, 115, 116, 117, 129, 132)

Brachynus melanarthrus Chaudoir, 1876:84. Lectotype, here selected, a male, MHNP, unlabelled, but standing first in box labelled "melanarthrus, Chaud. Caracas, Sallé." Type locality.—Mexico,

extends from French Guiana to Puerto Rico and Hispaniola that

as originally given by Chaudoir, but herewith restricted to Veracruz, Mexico.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Small to medium-sized beetles, 6.6 to 11.2 mm.

Color. As in *sallei*.

Microsculpture. As described for genus.

Macrosculpture. As in *sallei*.

Head. As in *sallei*, except mentum (fig. 19) without deep lateral pits and accessory setae and submentum without accessory setae.

Prothorax. As in *sallei*. Pronotum (fig. 111).

Pterothorax. As in *sallei*.

Abdomen. As described for genus.

Genitalia. Male (figs. 115, 116, 117). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend long. Apex of shaft narrowed, elongate. Ligule short, broadened apically. Virga (figs. 115, 116). Female (fig. 129). Stylus narrow, parallel-sided, narrowly rounded apically.

Variation.—Too few specimens are known of this species to analyze the geographical variation. However, the size may vary clinally, the largest specimens in Mexico, the smallest specimens in Honduras. One female from Veracruz is darker in color and the surface of the pronotum is dull due to very sense rugosities.

Flight.—These beetles have been collected at lights in the state of San Luis Potosi, Mexico.

Etymology.—Greek, *melanos* = black; *arthron* = joint; referring to the infuscated knees of these beetles.

Life history.—Members of this species have been collected in May, July, and August, but no teneral adults were seen.

Distribution.—(Fig. 132). The known range of this species extends from southern San Luis Potosi, Mexico, to northern Honduras. I have seen seven specimens from the following localities:

CENTRAL AMERICA

HONDURAS: (La Lima) DTRT; (Tela) DTRT.

MEXICO

SAN LUIS POTOSI: (Tamazunchale) MCZ. VERACRUZ: (5.0 miles northwest of Acayucan) UCD; (Veracruz) CNC.

4.55 The grandis group

The members of this group are characterized by very large size and darkly pigmented and elongate virgae. One species, B. grandis Brullé, is included.

4.5501 Brachinus grandis Brullé

(Figs. 113, 118, 119, 120, 127, 131)

Brachinus grandis Brullé, 1838:19. Lectotype, here selected, a female, MHNP, unlabelled, but standing next to a pin with a point and the label "grandis Brullé." The point holds the labrum of the specimen. Type locality.—Bolivia, as originally given by Brullé.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Very large-sized beetles, 16.4 to 18.5 mm.

Color. Mesepisterna, metepisterna, metasternum at sides,

abdominal sterna and terga, and "knees" infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra brown.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows rugose, sparsely punctate, punctures barely impressed.

Head. Frontal furrows moderately impressed. Antennal scape robust, widest apically. Ligula with sclerotized center area ellipsoid-convex with two apical setae. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 113), slightly flattened along center line, sides narrowly reflexed. Proepipleura glabrous, proepisterna with a few scattered setae both anteriorly and posteriorly. Anterior tibia with anterior surface sparsely punctate.

Pterothorax. Elytra elongate, broad, moderately costate. Humeral angle square. Pubescence confined to outer intervals, except in apical third. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 118, 119, 120). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend long. Apex of shaft narrowed to apex. Ligule poorly defined, short, truncate. Virga (figs. 118, 119). Female (fig. 127). Stylus very large, broad, narrowly rounded at apex.

Variation.—Too few specimens are known to evaluate geographic variation.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Latin, grandis = large; referring to the very large size of these beetles compared to others in the genus.

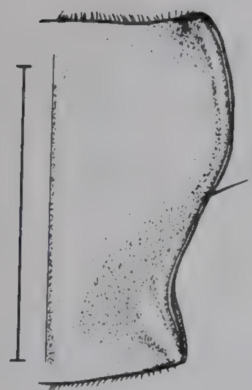
Life history.—Members of this species have been collected in March, May, and June, but no teneral adults were seen.

Distribution.—(Fig. 131). The known range of this species extends from Sinaloa and San Luis Potosi in Mexico to Bolivia, South America, but this has been determined by only four localities. It is probable that this species has discontinuous and local populations. I have seen five specimens from the following localities:

MEXICO

SINALOA: (Venedio) CAS. SAN LUIS POTOSI: (El Pujal) CPBo. TABASCO: (Macultepec) JHen.

Figs. 111-114. Pronotum, right half, dorsal aspect. 111. Brachinus melanarthrus Chaudoir, Tamazunchale, San Luis Potosi, Mexico. 112. Brachinus sallei Chaudoir, Edzna, Campeche, Mexico. 113. Brachinus grandis Brullé, Macultepec, Tabasco, Mexico. 114. Brachinus brunneus Castelnau, Laguna Guanico, Puerto Rico. Figs. 115-126. Male genitalia. 115. Brachinus melanarthrus Chaudoir, Veracruz, Veracruz, Mexico, ventral aspect. 116. Lateral aspect of same. 117. Dorsal aspect of same. 118. Brachinus grandis Brullé, Macultepec, Tabasco, Mexico, ventral aspect. 119. Lateral aspect of same. 120. Dorsal aspect of same. 121. Brachinus sallei Chaudoir, Coyame, Lake Catemaco, Veracruz, Mexico, ventral aspect. 122. Lateral aspect of same. 123. Dorsal aspect of same. 124. Brachinus brunneus Castelnau, La Guanica, Puerto Rico, ventral aspect. 125. Lateral aspect of same. 126. Dorsal aspect of same. Accompanying scale line equals 1.0 mm.



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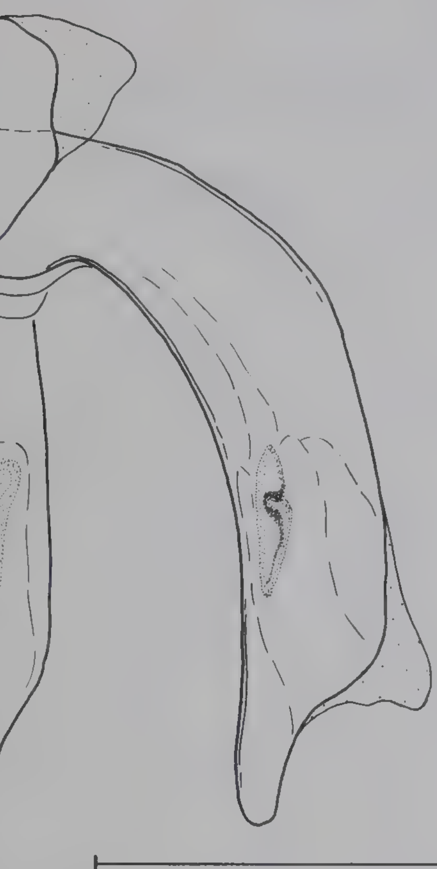

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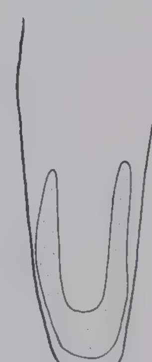

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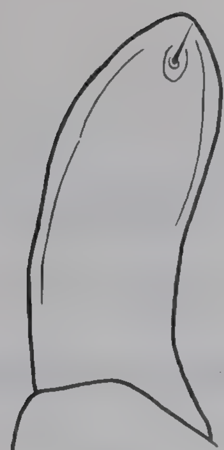
Figs. 127-130. Right stylus of female ovipositor, ventral aspect. 127. *Brachinus grandis* Brullé, Venedio, Sinaloa, Mexico. 128. *Brachinus sallei* Chaudoir, Edzna, Campeche, Mexico. 129. *Brachinus melanarthrus*, Tela, Honduras. 130. *Brachinus brunneus* Castelnau, Humacao, Puerto Rico. Figs. 131-134. Geographical distribution maps. 131. *Brachinus grandis* Brullé. 132. *Brachinus melanarthrus* Chaudoir. 133. *Brachinus sallei* Chaudoir. 134. *Brachinus brunneus* Castelnau. Accompanying scale line equals 1.0 mm.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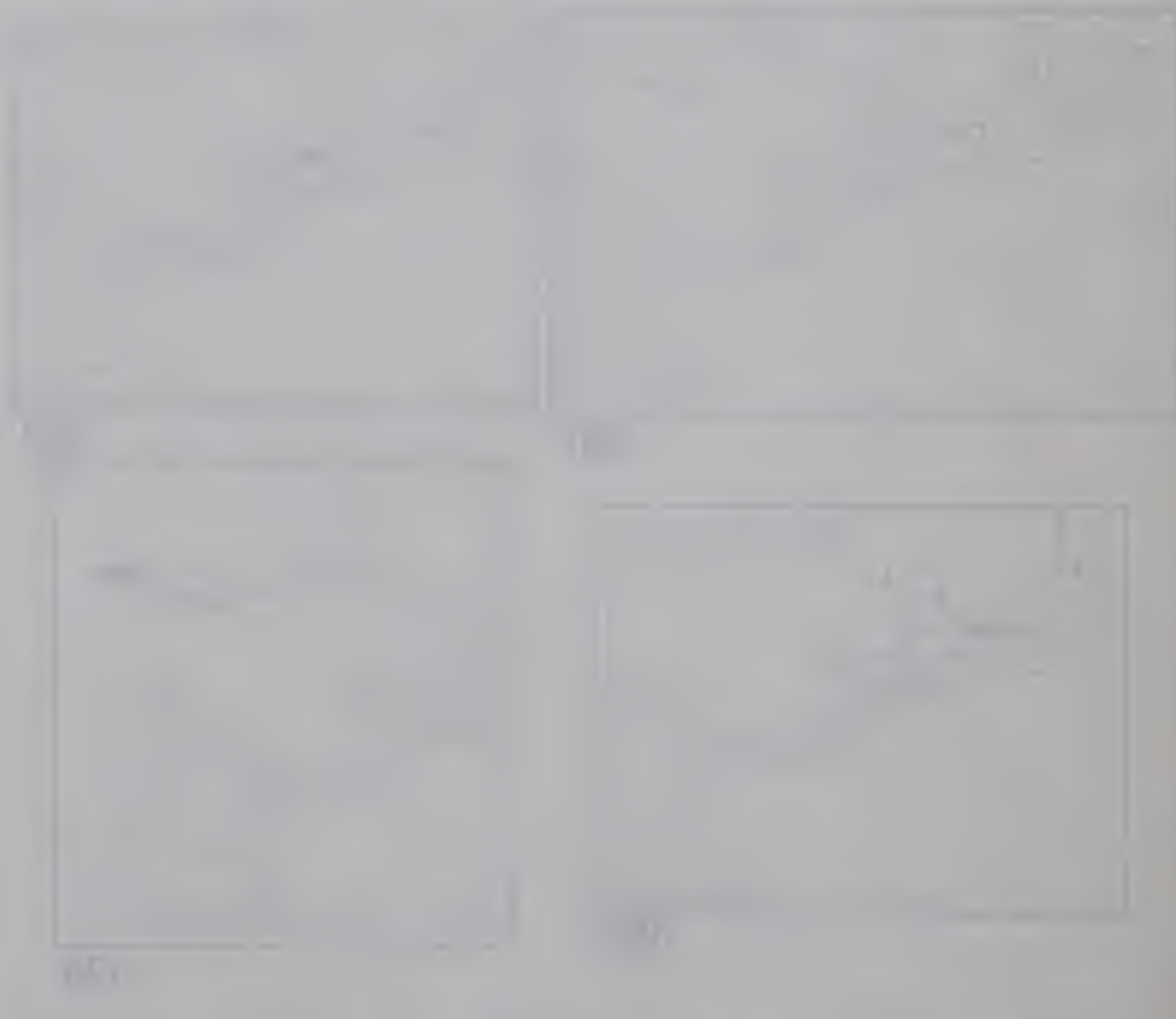


4.56 The lateralis group

The members of this group are characterized by their brown elytra. It is a provisional group pending the outcome of a revision of the South American species many of which have brown elytra.

4.5601 Brachinus lateralis Dejean
(Figs. 137, 145, 156, 157, 158, 169)

Brachinus lateralis Dejean, 1831:424. Lectotype, here selected, a male, MHNP, labelled "male, lateralis m. in Amer. bor." on green paper, "Ex Museo Chaudoir" and "Type" on red paper. Type locality.—North America, as originally given by Dejean, but herewith restricted to Imperial County, California.

Brachinus leucoloma Chaudoir, 1868:301. Lectotype, here selected, a male, MHNP, labelled "Californie, R. Gila, LeConte" and "Ex Museo Chaudoir." Type locality.—Gila River, Imperial County, California, as originally given on Chaudoir's labelled specimen. Erwin, 1965:7.

Diagnostic combination.—The brown elytra with pale epipleura and glabrous elytral disc separate members of this species from all others west of the continental divide in the United States. In Mexico and further south, only the genitalic characteristics provide reliable diagnostic characteristics (see key step 17).

Description.—Medium-sized beetles, 6.1 to 9.3 mm.

Color. Mesepisterna, metepisterna, abdomen at least at sides, and "knees" infuscated. Head and prothorax ferrugineous. Usually mouth parts, antennal articles 1-4, legs, and middle of venter testaceous.

Dorsal surface of elytra brown, epipleura testaceous.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows rugose, sparsely punctate. Surface of pronotum smooth with a few scattered shallowly impressed setiferous punctures.

Head. Frontal furrows shallowly impressed. Antennal scape robust, widest at middle. Ligula with sclerotized center area ellipsoid-convex with two apical setae, and a few small inconspicuous setae. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 137) convex, sides narrowly reflexed. Proepipleura glabrous. Proepisterna with a few setae anteriorly. Anterior tibia with anterior surface finely punctate.

Pterothorax. Elytra moderately long, barely costate. Humeral angle square. Pubescence usually confined to outer depressions and costae with some scattered patches occasionally on disc. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 156, 157, 158). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend moderately long. Apex of shaft flattened, ridged around edge and with a median ventral keel. Shaft swollen slightly at middle. Ligule short, truncate. Virga (figs. 156, 157). Female (fig. 145). Stylus long, narrow, apically rounded.

Variation.—Intrapopulational variation occurs in the following characteristics: the presence or absence of pubescence on the elytral disc, shade of brown color of the elytra, the height of the costae, the shape of the pronotum, and body size.

Flight.—The flight of these beetles has been recorded at lights throughout the range of the species.

Etymology.—Latin, lateralis = of the side; referring to the pale epipleura of the elytra on these beetles.

Collecting notes.—These beetles occur in a number of habitats. In California, they have been collected on the shores of the Salton Sea (saline) and Lake Elsinore (fresh water). In Arizona, they have been collected at the edges of lakes and in wet meadows. In Mexico, they have been collected in gravel beneath larger stones at the edges of streams.

Life history.—Members of this species have been collected in all months of the year. I have seen teneral adults collected in March in Puebla, in May and September in Sonora, and in August in California. These beetles probably overwinter (or aestivate) as adults.

Distribution.—(Fig. 169). The range of this species extends from northern Arizona south to Chiapas, Mexico, and populations occur in Baja California. I have seen 458 specimens from the following localities:

MEXICO

BAJA CALIFORNIA: (20.0 miles north of Comondu) CAS; (Estero, at mouth of Arroyo Rosario) CAS; (San Ignacio) CAS; (65.0 kilometers south of Tijuana) LACM. CHIAPAS: (20.9 miles north of Arriaga) UASM. DURANGO: (Durango City) AMNH, MCZ. GUANAJUATO: (Lago Yuriria, near Yuriria) UASM. GUERRERO: (Cacahuamilpa) JHen; (2.0 miles north of El Mogote) UASM; (Rio Mezcala, 23.7 miles north of Zumpango) UASM; (9.0 miles north of Zumpango) ISUA. JALISCO: (Ajijic) JHen, UATA; (Guadalajara) AMNH. MICHOACAN: (Morelia) AMNH, UASM; (Near Tzintzuntzan) UASM.

MORELOS: (Cañon de Lobos, 9.1 miles east of Cuernavaca) UASM; (Cuernavaca) ANSP, BMNH, RTBe; (Progreso) CUNY, WSUP; (Xochitepec) JHen. NAYARIT: (San Blas) CAS; (Tepic) UATA; (19.0 miles southeast of Tepic) CAS. OAXACA: (25.0 miles south of Mitla) ISUA; (Puente Zanatepec, near Zanatepec) UASM; (Rio Atoyac, near Juchatengo) UASM; (Rio Niltepec, 18.4 miles west of Zanatepec) UASM; (72.5 miles south of Valle Nacional) UASM. PUEBLA: (Puente Tepexco, near Tepexco) UASM; (near Petlalcingo) UASM; (near Tepexco) UASM. SINALOA: (13.0 miles north of Guamuchil) GRNo; (Los Mochis) CAS, GRNo; (Mazatlan) AMNH, CNC. SONORA: (10.0 miles west of Alamos) AMNH; (Ciudad Obregon) CNC; (16.0 miles northeast of Ciudad Obregon) CNC; (35.0 miles northeast of Ciudad Obregon) CNC; (14.0 miles southeast of Empalme) CAS; (Hermosillo) AMNH; (La Atascosa) UASM; (Navajoa) GRNo, JHen; (Pesqueria) CAS; (Rio Yagui 12.0 miles west of Ciudad Obregon) CNC; (Sonoyta) AMNH. VERACRUZ: (Jalapa) BMNH.

UNITED STATES

ARIZONA: Cochise County (Benson) CAS, (San Bernardino Ranch) KSU, LACM; Graham County (Thatcher) UCD; Maricopa County (Phoenix) MCZ, UATA, USNM; Mohave County (Littlefield) UCD; Pima County (Arivaca Creek at Arivaca) CAS, (Baboquivari Mountains, Browns Canyon) AMNH, (Santa Catalina Mountains) CAS, UATA, (Tucson) AMNH, ANSP, CAS, USNM; Pinal County (Picacho) CAS; Santa Cruz County (6.0 miles north of Nogales) UASM, (15.0 miles northwest of Nogales) UCD, (Pajarita Mountains) CAS, (Patagonia) CUNY, UATA, (Peña Blanca) UASM; Yuma County (Cibola) CAS, (Ehrenburg) UATA, (Fort Yuma) USNM, (Yuma) CAS, ISNH, MCZ, USNM; County unknown (Senator) AMNH. CALIFORNIA: Imperial County (Calpatria) CAS, (El Centro) CAS; Los Angeles County

PSUU, USNM, ZMLS, (Cypress) LACM, (East Manhattan) LACM, (Lake Hodges) SDNHM, (Long Beach) CAS, (Los Angeles) CAS, (Pasadena) CAS, TLEr; Orange County (Anaheim) SDNHM, (Laguna Canyon) UCD; Riverside County (Blythe) LACM, UIMI, (Corona) UCD, (Elsinore) CAS, (Lake Elsinore) CAS, CMPP, UIMI, UNLN, USNM, (Mecca) CVMA, (Riverside) CUNY, LACM, UMAH, USNM, (Salton Sea) VVBa, (Salton Sea, Mecca) CNC, USNM; San Bernardino County (Needle) CAS, (Ontario) CAS, (San Bernardino) MCZ, OUCO, (Saratoga Springs, Death Valley) UCD; San Diego County ANSP, CCha, CUNY, (Oceanside) CAS, (San Felipe Creek 14.0 miles east of Julian) UASM, (San Diego) SDNHM, (San Juan Capistrano) UIMI, (Sweetwater Valley) SDNHM. NEVADA: Clark County (Logandale) NSDA.

4.5602 Brachinus aeger Chaudoir

(Figs. 140, 144, 147, 148, 149, 168)

Brachynus aeger Chaudoir, 1876:82. Lectotype, here selected, a female, MHNP, labelled "Nouve Grenade," and standing first in a series of five specimens. Type locality.—Colombia, South America, as originally given by Chaudoir.

Diagnostic combination.—Only the genitalia provide reliable diagnosis, but see key step 18.

Description.—Small to medium-sized beetles, 5.8 to 8.9 mm.

Color. As in lateralis, except mesepisterna usually pale.

Microsculpture. As described for genus.

Macrosculpture. As in lateralis.

Head. As in lateralis, except ligula without inconspicuous setae.

Prothorax. As in lateralis. Pronotum (fig. 140).

Pterothorax. As in lateralis, except costae weaker.

Abdomen. As described for genus.

Genitalia. Male (figs. 147, 148, 149). Median lobe with plane of shaft barely rotated from plane of basal bend. Basal bend long. Shaft bulbous at basal third; narrowed to acute boot-shaped apex; venter ridged medially. Ligule moderately long, broad, rounded apically. Virga (figs. 147, 148). Female (fig. 144). Stylus short, parallel-sided, narrowly rounded at apex.

Variation.—As in lateralis, except disc of elytra generally pubescent.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Latin, aeger = sick, troubled; referring, I think, to the pale colors of these beetles compared to others in the genus.

Collecting notes.—G. E. Ball and D. R. Whitehead have collected these beetles on gravel banks of several rivers in Mexico.

Life history.—Members of this species have been collected from April to June and November to January, but no teneral adults were seen.

Distribution.—(Fig. 168). The range of this species extends from Sonora, Mexico, south to Colombia, South America. Most records are from the western coast of Mexico, but one specimen was collected in San Luis Potosi, Mexico. I have seen 15 specimens from the following localities:

CENTRAL AMERICA

GUATEMALA: (Paso Antonio, Escuintla) BMNH.

MEXICO

CHIAPAS: (Tuxtla Gutierrez) BMNH. GUERRERO: (Rio Mezcala, 23.7

miles north of Zumpango) UASM. NAYARIT: (Rio Acaponeta, 2.4 miles south of Acaponeta) UASM; (19.0 miles southeast of Tepic) CAS. OAXACA: (Oaxaca City) BMNH. SAN LUIS POTOSI: (El Pujal) CPBo. SINALOA: (Camino, Real de Piaxtla) AMNH. SONORA: (Ciudad Obregon) CNC; (Cocorit) UCR. TABASCO: (Rio Teapa, near Teapa) UASM. VERACRUZ: (San Andres Tuxtla) BMNH.

4.5603 *Brachinus chalchihuitlicue* new species

(Figs. 135, 143, 159, 160, 161, 167)

Type locality.—San Blas, Nayarit, Mexico.

Type specimens.—The holotype male and allotype female are in the entomological collections at CAS; both were collected at the type locality by B. Malkin on September 17-21, 1953. Four paratypes collected at various localities and on various dates are in AMNH, CAS, MCZ, TLEr, UASM.

Diagnostic combination.—Although members of this species have their elytral costae elevated more than any other in the group, the only reliable diagnostic characters are the genitalia, but also see key step 20.

Description.—Medium-sized beetles, 8.7 to 11.0 mm.

Color. Antennal articles 3 and 4, mesepimera, metepisterna, abdominal sterna at least at sides, abdominal terga, and "knees" infuscated, otherwise ferrugineous. Legs testaceous. Dorsal surface of elytra brown, epipleura slightly paler.

Microsculpture. As described for genus.

Macrosculpture. As in *lateralis*.

Head. As in *lateralis*, except ligula without minute setae.

Prothorax. As in lateralis. Pronotum (fig. 135).

Pterothorax. As in lateralis, except costae more highly elevated.

Abdomen. As described for genus.

Genitalia. Male (figs. 159, 160, 161). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend long. Apex of shaft very narrow, elongate. Ligule long and broad, rounded apically. Virga (figs. 159, 160). Female (fig. 143). Stylus broad, tapering to almost acute apex.

Variation.—Besides the intrapopulational variation in shape of the pronotum and in body size, these beetles vary locally in the height of their costae.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Chalchihuitlicue, the goddess of runoff waters, streams, lakes, and the sea, in early Teotihuacan and Nahuat-Toltec cultures of central Mexico. This goddess is also the wife of Tlaloc, the god of rain and thunder. The name refers to the habitat in which most Brachinus species are found.

Life history.—Members of this species have been collected from July to September. Teneral adults were collected in July in Sinaloa and in August in Guerrero.

Distribution.—(Fig. 167). The known range of this species extends from Sinaloa to Guerrero on the west coast of Mexico. I have seen 30 specimens from the following localities:

MEXICO

GUERRERO: (Acapulco) MCZ. NAYARIT: (San Blas) CAS; (Tepic) AMNH. SINALOA: (Mazatlan) AMNH, GRNo, UCR; (Venedio) CAS. STATE UNKNOWN: (Saltillo) MCZ.

4.5604 *Brachinus arboreus* Chevrolat

(Figs. 138, 146, 150, 151, 152, 170)

Brachinus arboreus Chevrolat, 1834:42. Lectotype, here selected, a male, HMO, Type number COL. 114 1/3, further labelled "Brachinus arboreus Chev. Col. Mex. 1 cent No 2 Mexico Sallé." *Type locality*.—Orizaba, Mexico, as originally given by Chevrolat.

Diagnostic combination.—Only the genitalia provide reliable diagnosis, but see also key step 21.

Description.—Small to medium-sized beetles, 6.1 to 9.2 mm.

Color. Base of antennal articles 3 and 4, mesepisterna, metepisterna, abdominal sterna at least at sides, abdominal terga, and "knees" infuscated, otherwise ferrugineous. Dorsal surface of elytra brown, epipleura seldom paler.

Microsculpture. As described for genus.

Macrosculpture. As in *lateralis*.

Head. As in *lateralis*, except ligula without inconspicuous setae.

Prothorax. As in *lateralis*. Pronotum (fig. 138).

Pterothorax. As in *lateralis*.

Abdomen. As described for genus.

Genitalia. Male (figs. 150, 151, 152). Median lobe with plane of shaft barely rotated from plane of basal bend. Basal bend short. Apex of shaft narrowed, acute, ridged ventrally at middle and at sides forming two small sulci. Ligule short, broad, truncate. Virga (figs. 150, 151). Female (fig. 146). Stylus narrow, parallel-sided, slightly curved, narrowly rounded apically.

Variation.—As in *lateralis*.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Latin, *arboreus* = of the trees. The reason Chevrolat gave this name is unexplained in his description.

Collecting notes.—D. R. Whitehead has collected these beetles along a small stream in Jalisco.

Life history.—Members of this species have been collected in January, March, June, and November, but no teneral adults were seen.

Distribution.—(Fig. 170). The range of this species extends from Sinaloa south to Honduras. I have seen 57 specimens from the following localities:

CENTRAL AMERICA

HONDURAS: (La Lima) DTRT.

MEXICO

JALISCO: (9.0 miles east of Guadalajara) AMNH. NAYARIT: (32.0 miles south of Acaponeta) CAS; (19.0 miles southeast of Tepic) CAS. MORELOS: (5.0 miles east of Cuernavaca) UCD. SINALOA: (Mazatlan) TLEr; (Rosario) CAS. VERACRUZ: (Cordoba) BMNH; (Jalapa) BMNH.

4.5605 *Brachinus chirriador* new species

(Figs. 136, 141, 162, 163, 164, 165)

Type locality.—Six miles west of Cintalapa, Route 190, Chiapas, Mexico.

Type specimens.—The holotype male and allotype female are in the MCZ. The holotype was collected by G. E. Ball and D. R. Whitehead at the type locality on September 7, 1965. The allotype was collected at Jacala, Hidalgo by R. Haag on June 23, 1939. Two paratypes

collected on various dates at various localities are in CAS, CPBo, TLEr, UASM.

Diagnostic combination.—The restriction of elytral pubescence to depressions 7 and 8 in the basal two-thirds of the elytra will usually separate these beetles from others with brown elytra in Mexico and Central America. Only the genitalia provide reliable diagnosis, however.

Description.—Medium-sized beetles, 7.2 to 10.0 mm.

Color. As in lateralis, except epipleura dark.

Microsculpture. As described for genus.

Macrosculpture. As in lateralis.

Head. As in lateralis.

Prothorax. As in lateralis, except anterior tibia with anterior surface finely strigose. Pronotum (fig. 136).

Pterothorax. As in lateralis, except pubescence restricted to depressions 7 and 8.

Abdomen. As described for genus.

Genitalia. Male (figs. 162, 163, 164). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend short. Apex of shaft narrow, slightly elongate. Ligule short, broad, truncate. Virga (figs. 162, 163). Female (fig. 141). Stylus very broad, tapering apically to narrowly rounded apex.

Variation.—Too few specimens are known to evaluate geographic variation.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Mexican-Spanish, chirriador = the one who crepitates.

Collecting notes.—G. E. Ball and D. R. Whitehead collected these

beetles at the edge of a pond at the type locality by treading coarse grass and emergent vegetation.

Life history.—Members of this species have been collected from April to June, and August to December, but no teneral adults were seen.

Distribution.—(Fig. 165). The known range of this species extends from northern Tamaulipas, Mexico, south along the east coast to Honduras and on the west coast of Mexico in Sinaloa and Nayarit. I have seen 11 specimens from the following localities:

CENTRAL AMERICA

HONDURAS: (La Lima) DTRT.

MEXICO

CHIAPAS: (6.0 miles west of Cintalapa) UASM. JALISCO: (Puente La Garita, near La Garita) UASM. NAYARIT: (San Blas) CAS. SAN LUIS POTOSI: (El Pujal) CPBo. TAMAULIPAS: (La Coma, Aldama) CPBo. VERACRUZ: (Veracruz) UCD.

4.5606 *Brachinus adustipennis* new species

(Figs. 139, 142, 153, 154, 155, 166)

Type locality.—Myakka River, Myakka River State Park, Sarasota County, Florida.

Type specimens.—The holotype male and allotype female are in MCZ; both were collected at the type locality by T. L. and L. J. Erwin on May 29, 1968. Five paratypes collected at various localities and on various dates are in AMNH, CAS, DRWh, MCZ, TLEr, and UASM.

Diagnostic combination.—The brown elytra and pale epipleura, and pubescent elytral disc separate members of this species from all

others east of the continental divide in the United States. In Mexico and further south only the genitalic characters provide reliable separation, but see also key step 17.

Description.—Medium-sized beetles, 6.0 to 10.2 mm.

Color. Metepisterna, "knees" and sides of abdominal sterna infuscated. Antennal articles 3 and 4, usually terga slightly infuscated, otherwise body and limbs testaceous to ferrugineous. Dorsal surface of elytra brown, epipleura usually paler.

Microsculpture. As described for genus.

Macrosculpture. As in *lateralis*.

Head. As in *lateralis*, except minute ligula setae apparently absent.

Prothorax. As in *lateralis*, except anterior tibia with anterior surface strigose. Pronotum (fig. 139).

Pterothorax. As in *lateralis*, except disc of elytra usually pubescent, and costae weaker.

Abdomen. As described for genus.

Genitalia. Male (figs. 153, 154, 155). Median lobe with plane of shaft barely rotated from plane of basal bend. Basal bend moderately long. Apex of shaft narrowed, rounded, and ridged ventrally; lateral ridges less prominent than in *lateralis*, ending before apex; apex slightly bent dorsally. Ligule short, narrowed toward rounded apex. Virga (figs. 153, 154). Female (fig. 142). Stylus narrow, broadened slightly at apical third, rounded apically.

Variation.—As in *lateralis*, except disc of elytra usually pubescent.

Flight.—The flight of these beetles has been recorded at lights

throughout the range of the species.

Etymology.—Latin, adustus = tanned, brown; pennis = wing; referring to the tan-colored elytra of these beetles.

Collecting notes.—My wife and I collected these beetles in a number of localities in the southern United States. Along the Myakka River, at the type locality, they occurred beneath boards and stones on the River's grassy banks. At Juniper Springs, Florida, and in the Okefenokee Swamp, we found them in the roots of grass clumps in *Sciripus*-*Typha* marshes. In Texas they occurred on the muddy banks of the San Jacinto River in grassy clumps.

Life history.—Members of this species have been collected from March to December. Teneral adults were collected in May in Florida, and in August in Tennessee. Overwintering (or aestivating) probably occurs in the adult state.

Distribution.—(Fig. 166). The range of this species extends from New York and Michigan, west to the west coast of Mexico, south to Panama. One specimen is labelled Cuba. I have seen 552 specimens from the following localities:

CENTRAL AMERICA

PANAMA: (La Chorrera) CAS.

GREATER ANTILLES

CUBA: (No locality given) TMBH.

MEXICO

AGUASCALIENTE: (15.0 miles west of Pabellon) UMAH. NAYARIT: (Acaponeta) AMNH; (32.0 miles south of Acaponeta) CAS. SINALOA: (Los Mochis) CAS; (Mazatlan) AMNH, CAS, UASM; (20.0 miles west of Rosario) UCR; (Venedio) CAS. SONORA: (16.0 miles northeast of

Ciudad Obregon) CNC; (Hermosillo) CNHM; (Rio Yagui, 12.0 miles west of Ciudad Obregon) CNC. TABASCO: (San Juan Bautista) BMNH; (Villa Hermosa) FDAG. TAMAULIPAS: (9.9 miles west of La Pesca) UASM. VERACRUZ: (Veracruz) UASM. YUCATAN: (Uxmal) TLEr.

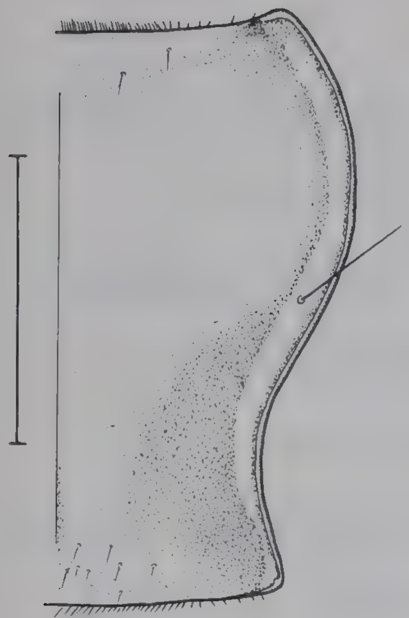
UNITED STATES

ALABAMA: Mobile County (Mobile) ANSP, USNM. ARKANSAS: Arkansas County (Almyra) USNM; Desha County (No locality given) UAFA; Hempstead County (Hope) CAS, MCZ; Poinsett County (No locality given) UAFA; Pulaski County (Little Rock) AMNH; Washington County (No locality given) UAFA. FLORIDA: Alachua County (Gainesville) FDAG, UMAH, (Payne's Praire) UMAH; Brevard County (Indian River) USNM; Citrus County CAS, USNM, (Inverness) MCZ; Collier County (Naples) CUNY; Columbia County (Lake City) DRWh; Dade County (Florida City) UASM, (Miami) CMPP, (Royal Palm State Park) PUM; Escambia County (Pensacola) FDAG; Hernando County (Brooksville) CAS; Highlands County (Archbold Biology Station) CEWh, PSUU; Hillsborough County (Tampa) CAS, UMSP; Lake County USNM, (Fruitland Park) ANSP, UMAH, (Groveland) FDAG, (5.6 miles east of Juniper Springs) TLEr; Lee County (Fort Myers) PUM; Levy County (Cedar Keys) USNM, (Manatee Springs State Park) RFre, UASM; Manatee County (Oneco) UASM; Marion County (No locality given) MCZ; Osceola County (Kissimmee) MCZ, PUM, UCD, USNM; Palm Beach County (Lake Worth) CAS; Pasco County (Dade City) FDAG; Pinellas County (Clearwater) CNHM, (Dunedin) AMNH, CAS, CUNY, UMAH, UWMW, (Tarpon Springs) AMNH, CNHM; Putnam County (Crescent City) USNM; Sarasota County (Myakka River State Park) TLEr, UASM, (Sarasota) PUM; Seminole County (Lake Harney) USNM; Volusia County (Enterprise) CAS, ISNH, OUCO, UMSP, USNM; County unknown (Fort Capron) ISNH.

GEORGIA: Baker County (Newton) CNC; Tift County (Tifton) OUCO; Ware County (8.0 miles northeast of Fargo) TLEr. ILLINOIS: Richland and Lawrence Counties (Wabash) MCZ. INDIANA: Floyd County (New Albany) CEWh; Posey County (No locality given) PUM. KANSAS: Douglas County (Lawrence) PUM. LOUISIANA: USNM, Acadia Parish (Crowley) CAS; Allen Parish (Kinder) UASM; Calcasieu Parish (Lake Charles) USNM, (Sam Houston State Park) CUNY, TLEr; East Baton Rouge Parish UAFA, (Baton Rouge) LSUB, UMAH; Evangeline Parish (Lake Chicot State Park) TLEr; Franklin Parish (Chase) UAFA; Iberia Parish (Avery Island) ANSP; Jefferson Parish (Harahan) CNHM; Livingston Parish (Denham Springs) LSUB; Madison Parish (Tallulah) TAMU; Orleans Parish (New Orleans) ANSP, CAS, LACM, MCZ, USNM, UWMW, WSUP; Ouachita Parish (Calhoun) UAFA; Saint John the Baptist Parish (Garyville) LSUB; Saint Martin Parish (No locality given) UAFA; Vermilion Parish (Gueydan) USNM; Vernon Parish (Rosepine) UAFA; Parish unknown (Mound) FDAG. MICHIGAN: Benzie County (No locality given) PUM. MISSISSIPPI: Hinds County (Jackson) UCR; County unknown (McCormick) UWSW. MISSOURI: Boone County (Columbia) UCD; Saint Louis County (Saint Louis) UCR. NEW MEXICO: Chaves County (Roswell) UWSW. NEW YORK: Westchester County (Peekskill) MCZ. OKLAHOMA: Carter County (Ardmore) OSUS. TENNESSEE: Davidson County (Nashville) USNM; Madison County (Jackson) CNC. TEXAS: Atascosa County (Pleasanton) TAMU; Blanco County (Cypress Mills) USNM; Brazos County (College Station) TAMU; Cameron County (Brownsville) CAS, CNC, CUNY, OUCO, TLEr, USNM; Colorado County (No locality given) UMSP; Dallas County (Dallas) MCZ; El Paso County (El Paso) CMPP; Fayette County (Engle) CAS; Frio County (5.0 miles north of Dilley) UASM; Hardin

County (9.0 miles west of Beaumont) OSUC; Harris County USNM, (Highway 59 at San Jacinto River, near Houston) TLEr; Harrison County (near Sabine River) TCBa; Hidalgo County (Mercedes) USNM, (Weslaco) TAMU; Jefferson County (20.0 miles southwest of Sabine Pass) RCGr; Kerr County (Kerrville) CNC; Kleberg County (Kingsville) CUNY; Lee County (No locality given) UMAH; Smith County (Lake Palestine, 17.0 miles southwest of Tyler) DRWh; Travis County (Austin) CAS; Val Verde County (Del Rio) CNC.

Figs. 135-140. Pronotum, right half, dorsal aspect. 135. _Brachinus chalchihuitlicue_ new species, San Blas, Nayarit, Mexico. 136. _Brachinus chirriador_ new species, Puente La Garita, La Garita, Jalisco, Mexico. 137. _Brachinus lateralis_ Dejean, 20.9 miles north of Arriaga, Chiapas, Mexico. 138. _Brachinus arboreus_ Chevrolat, Mazatlan, Sinaloa, Mexico. 139. _Brachinus adustipennis_ new species, 20.0 miles west of Rosario, Sinaloa, Mexico. 140. _Brachinus aeger_ Chaudoir, Paso Antonio, Escuintla, Guatemala. Figs. 141-146. Right stylus of female ovipositor, ventral aspect. 141. _Brachinus chirriador_ new species, Puente La Garita, La Garita, Jalisco, Mexico. 142. _Brachinus adustipennis_ new species, 20.0 miles west of Rosario, Sinoloa, Mexico. 143. _Brachinus chalchihuitlicue_ new species, Mazatlan, Sinaloa, Mexico. 144. _Brachinus aeger_ Chaudoir, Paso Antonio, Escuintla, Guatemala. 145. _Brachinus lateralis_ Dejean, Rio Niltepec, Oaxaca, Mexico. 146. _Brachinus arboreus_ Chevrolat, Mazatlan, Sinaloa, Mexico. Accompanying scale lines equal 1.0 mm.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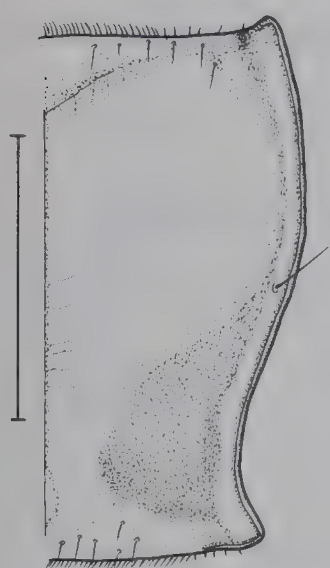
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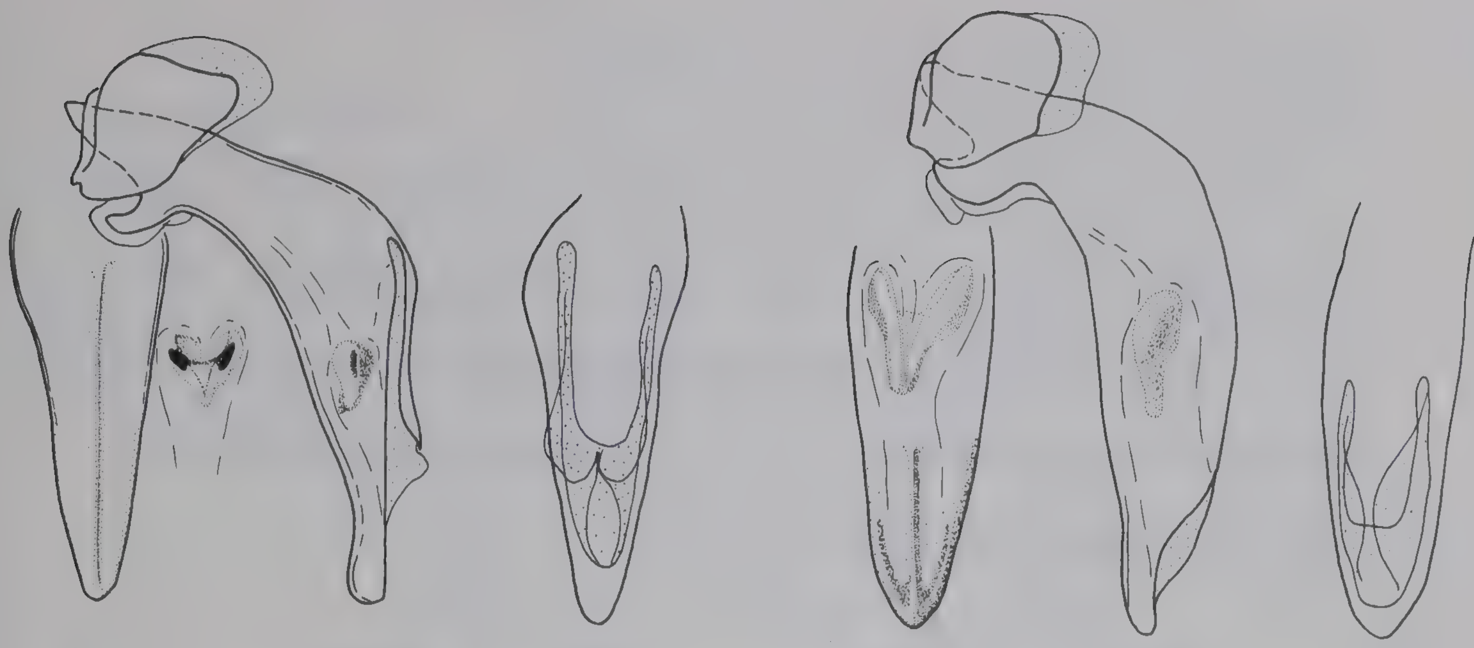
Figs. 147-164. Male genitalia. 147. *Brachinus aeger* Chaudoir, Rio Teapa, Tabasco, Mexico, ventral aspect. 148. Lateral aspect of same. 149. Dorsal aspect of same. 150. *Brachinus arboreus* Chevrolat, 32.0 miles south of Acaponeta, Nayarit, Mexico, ventral aspect. 151. Lateral aspect of same. 152. Dorsal aspect of same. 153. *Brachinus adustipennis* new species, Manatee Springs State Park, Florida, ventral aspect. 154. Lateral aspect of same. 155. Dorsal aspect of same. 156. *Brachinus lateralis* Dejean, near Petalcingo, Puebla, Mexico, ventral aspect. 157. Lateral aspect of same. 158. Dorsal aspect of same. 159. *Brachinus chalchihuitlicue* new species, San Blas, Nayarit, Mexico, ventral aspect. 160. Lateral aspect of same. 161. Dorsal aspect of same. 162. *Brachinus chirriador* new species, Puente La Garita, La Garita, Jalisco, Mexico, ventral aspect. 163. Lateral aspect of same. 164. Dorsal aspect of same. Accompanying scale lines equal 1.0 mm.



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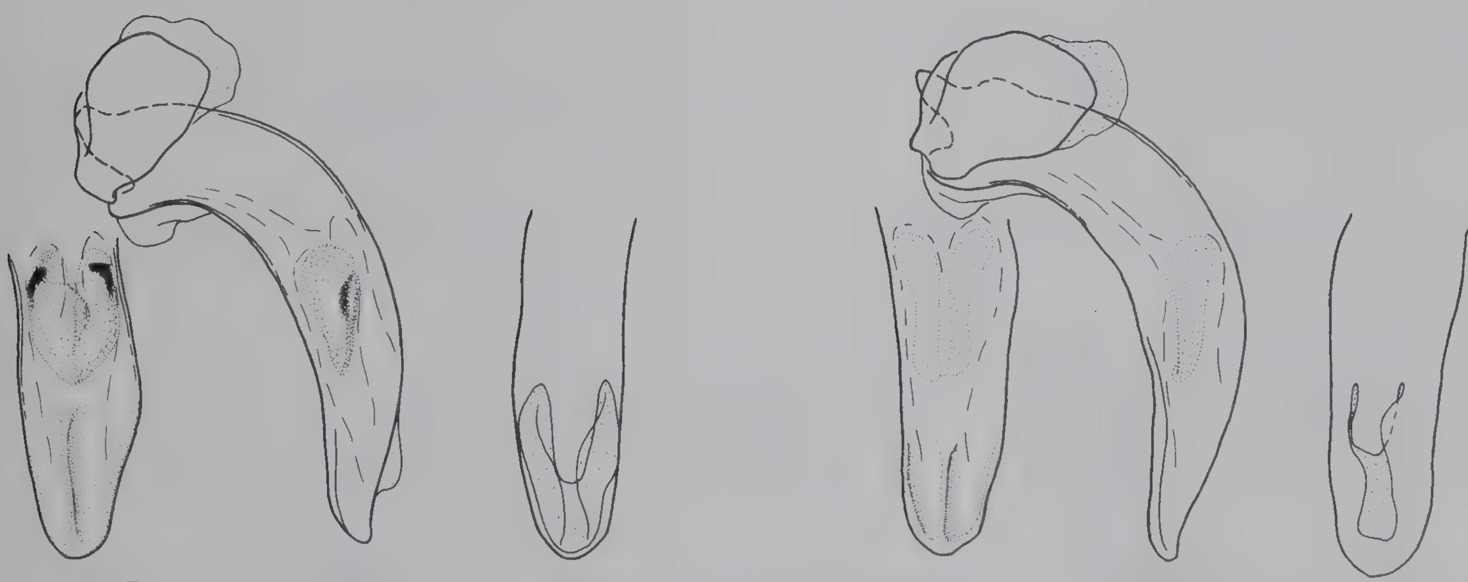

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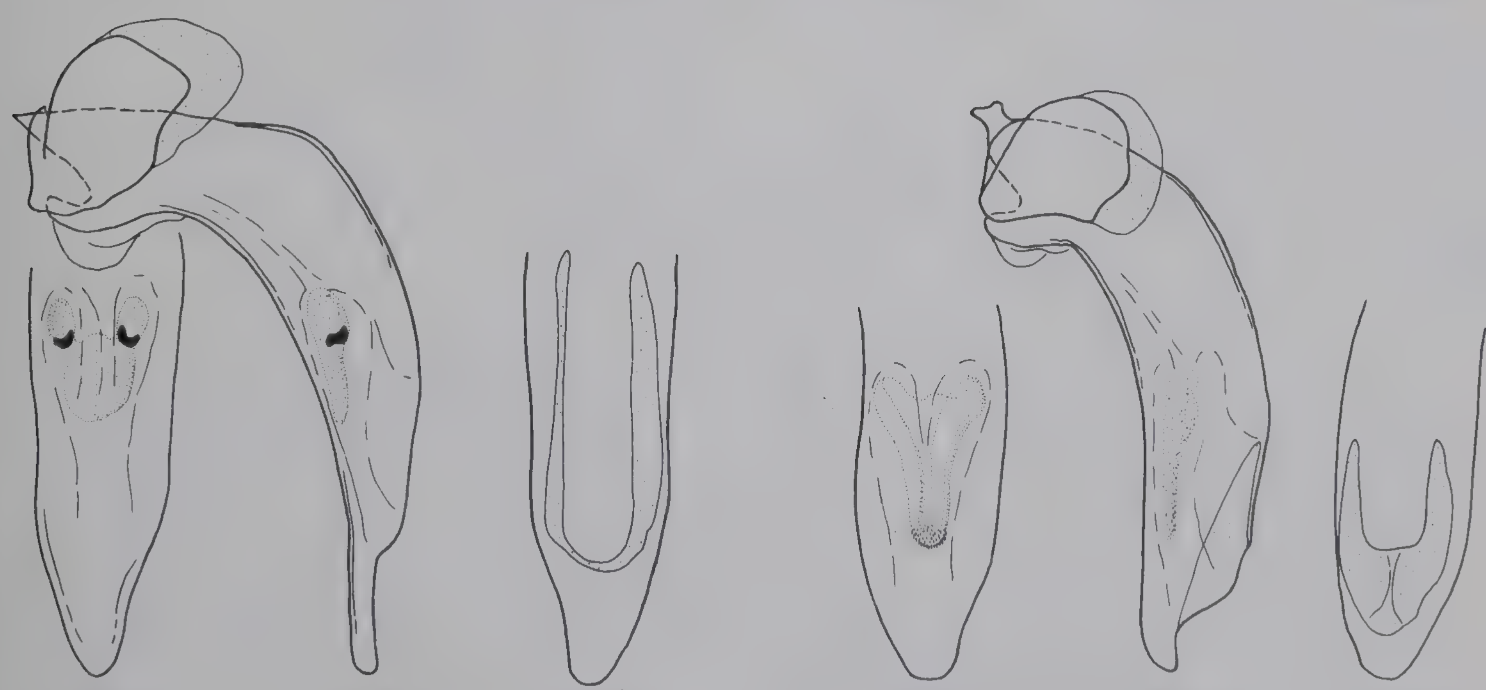
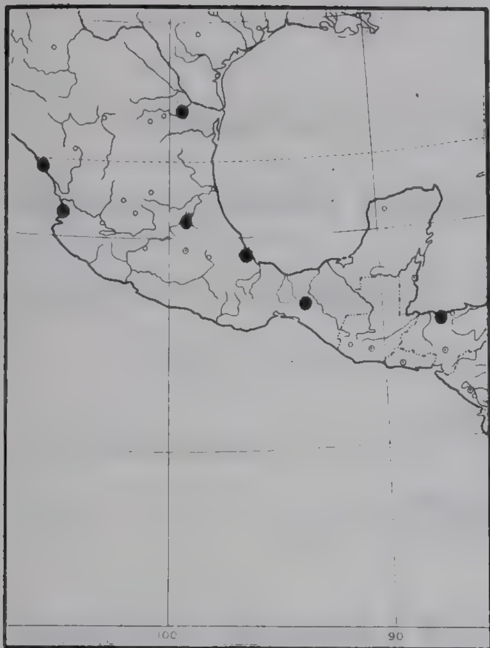


159 160 161 162 163 164

Figs. 165-170. Geographical distribution maps. 165. *Brachinus chirriador* new species. 166. *Brachinus adustipennis* new species. 167. *Brachinus chalchihuitlicue* new species. 168. *Brachinus aeger* Chaudoir. 169. *Brachinus lateralis* Dejean. 170. *Brachinus arboreus* Chevrolat.



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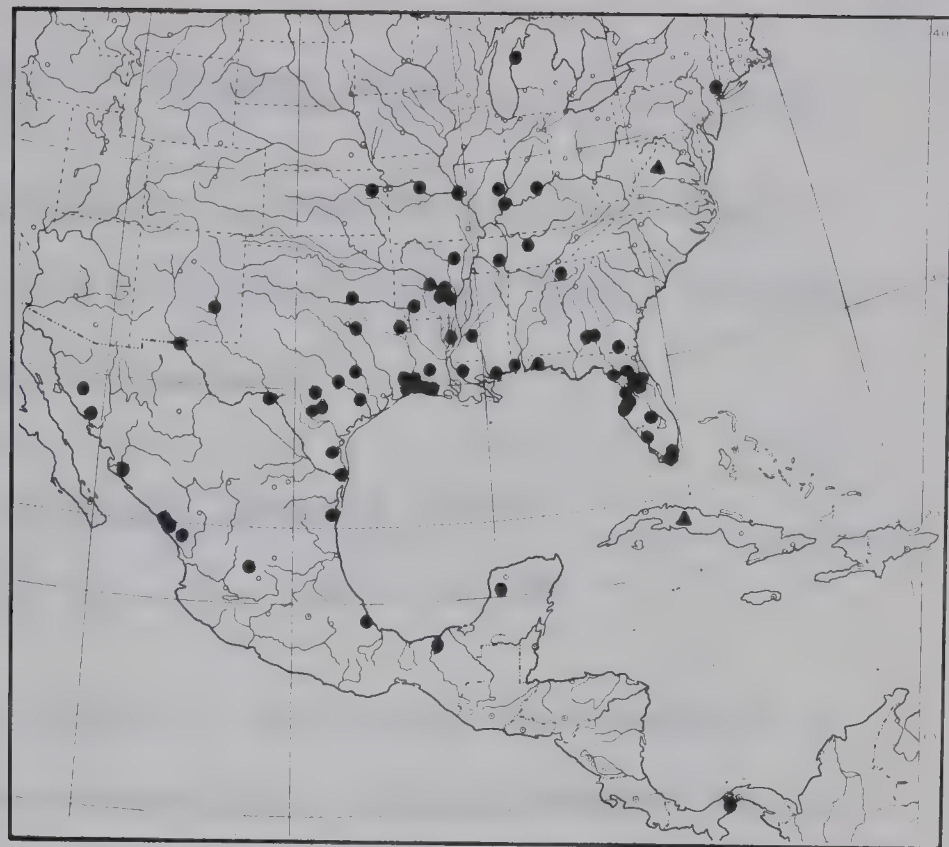

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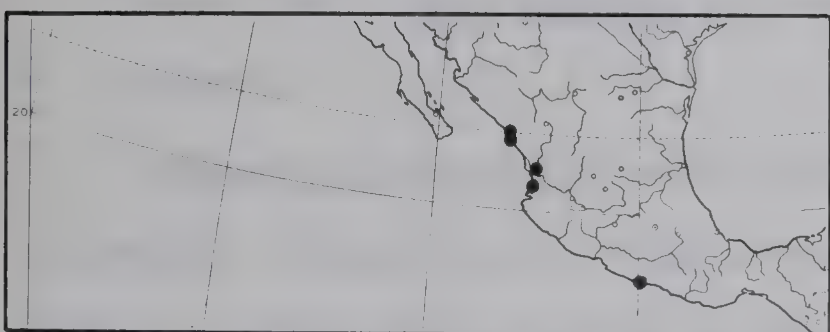

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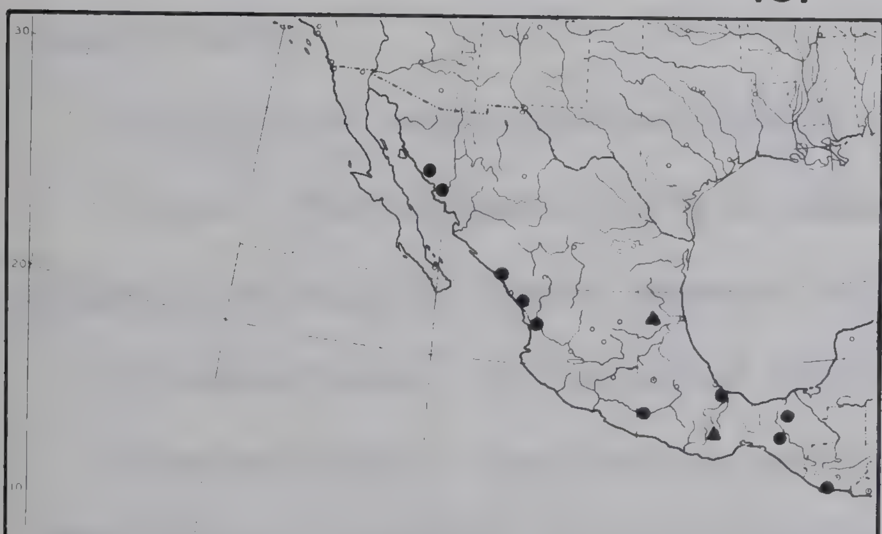

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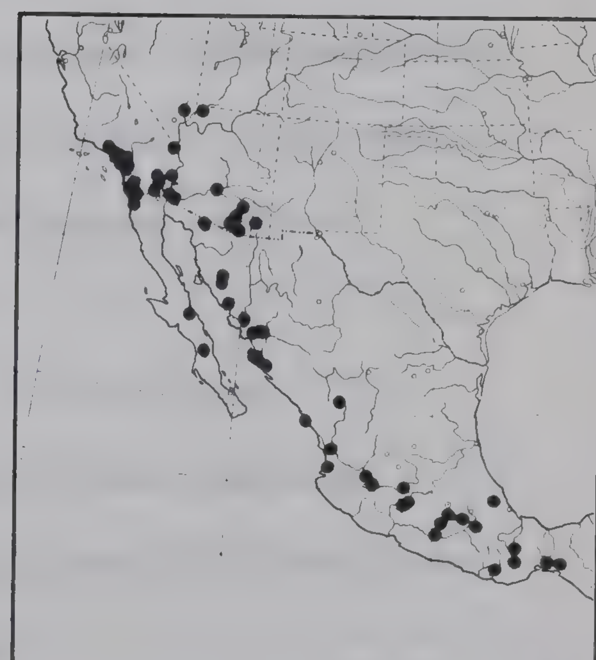

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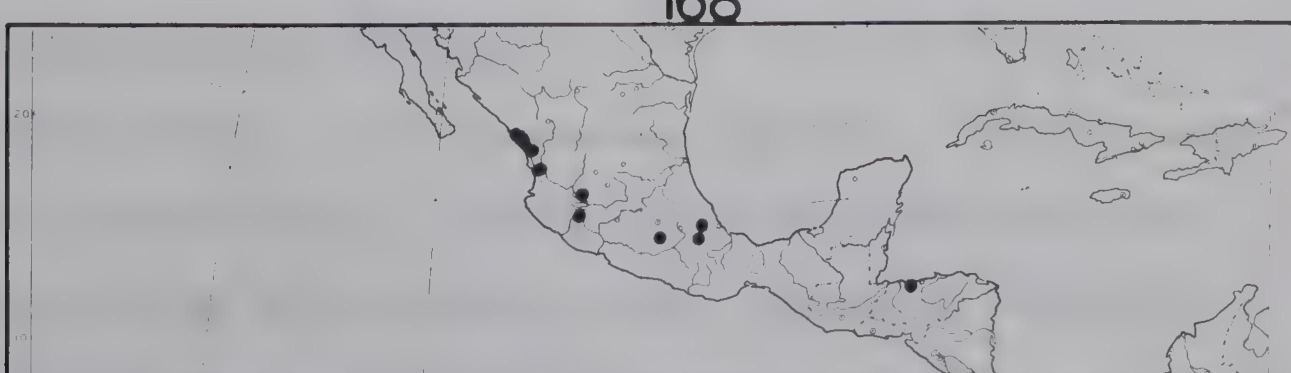


170

4.57 The kansanus group

This group is characterized by its large shield-like virga, sharply costate elytra and lack of lateral pronotal setae. A single species, *B. kansanus* LeConte, is included.

4.5701 *Brachinus kansanus* LeConte
(Figs. 175, 176, 177, 178, 195, 198)

Brachinus kansanus LeConte, 1862:524. Lectotype, here selected, a male, MCZ red type label number 5851, further labelled with a green disc. Type locality.—Kansas, as originally given by LeConte.

Diagnostic combination.—This species is best characterized by its sharply costate elytra, lack of lateral pronotal setae, very narrowly reflexed sides of the pronotum, and almost glabrous proepipleura.

Description.—Medium-sized beetles, 8.7 to 11.5 mm.

Color. Ferrugineous, sides of abdomen of some specimens slightly infuscated. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Head behind eyes and frontal furrows rugose and shallowly punctate. Disc of pronotum with numerous shallowly impressed setiferous punctures.

Head. Frontal furrows moderately impressed. Antennal scape robust, widened apically. Ligula with sclerotized center area ellipsoid-convex with two apical setae. Mentum and submentum various, with or without accessory setae.

Prothorax. Pronotum (fig. 175) convex, flattened along center line, sides very narrowly reflexed. Proepipleura and proepisterna with a few scattered setae. Anterior tibia with anterior edge strigose.

Pterothorax. Elytra elongate, narrow, strongly costate. Humeral angle square. Costae smooth and glabrous, depressions between costae pubescent. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 176, 177, 178). Median lobe with plane of shaft rotated about 45° from plane of basal bend. Basal bend short. Median lobe nearly straight, slightly swollen at middle. Apex of shaft broadly rounded. Ligule short, very broad, truncate. Virga (figs. 176, 177). Female (fig. 195). Stylus elongate, narrow, parallel-sided, almost blunt apically.

Variation.—Besides the intrapopulational variation in body size and shape of the pronotum, these beetles vary in number of accessory setae of the mentum and submentum, the setal number of the ligula, and in the color of the elytra (blue to blue-green). The range of variation in all characteristics is seen in single population samples.

Flight.—The flight of these beetles has not been recorded.

Etymology.—The latinized form of Kansas, the place where the type was collected.

Collecting notes.—This species occurs along river and stream courses in very sandy areas beneath the broadleaf deciduous forest which follows these water courses into the Great Plains. K. L. Hays has also collected these beetles in the sand dunes near Manhattan,

Kansas.

Life history.—Members of this species have been collected from June to October. One teneral adult was collected in July in Oklahoma. Overwintering is probably in the adult stage.

Distribution.—(Fig. 198). This is the only species restricted to the Great Plains area. It occurs along eastward flowing tributaries of the Mississippi and Missouri Rivers. I have seen 95 specimens from the following localities:

UNITED STATES

ARKANSAS: Crawford County (No locality given) USNM. ?DAKOTA: (No locality given) MCZ. KANSAS: Atchison County (No locality given) CAS; Douglas County (No locality given) CMPP; Republic County (Republican River, Scandia) CAS; Riley County KSU, (Manhattan) USNM. ILLINOIS: Adams County (Quincy) CNHM; Calhoun County (Kampsville) MCZ. IOWA: Boone County (Ledges State Park) ISUA. MINNESOTA: (No locality given) UMSP. MISSOURI: (No locality given) ANSP, ISNH, MCZ, UMSP. NEBRASKA: Dodge County (Fremont) UNLN; Otoe County (Nebraska City) UNLN; Richardson County (Rulo) UNLN; Sioux County (Monroe Canyon) UNLN. OHIO: Preble County (No locality given) PUM. OKLAHOMA: Beckham County (No locality given) CAS; Cleveland County (No locality given) UONO; Grady County (Chickasha) USNM; Payne County (Stillwater) OSUS; Woodward County (Woodward) CNHM.

4.58 The costipennis group

This group is characterized by the form of the virga, form of the median lobe of the male genitalia, completely glabrous elytra, sulcate mentum surrounded by setae (shared with B. mobilis and

some Old World species), and abbreviated submentum. One species, _B. costipennis_ Motschulsky, is included.

4.5801 _Brachinus costipennis_ Motschulsky
(Figs. 18, 174, 186, 187, 188, 196, 197)

Brachinus costipennis Motschulsky, 1859:138. Lectotype, here selected, a female, MCZ red type label number 8329. Further labelled with a green square and "37." As I pointed out (1965:5), "this specimen is very likely a cotype from Motschulsky, with whom LeConte is known to have corresponded." _Type locality_.—California, as given originally by Motschulsky.

Brachinus carinulatus Motschulsky, 1859:139. Lectotype, here selected, a male, MMM, labelled with a green square and "Brachynus carinulatus Motsch. California." _Type locality_.—California, as originally given by Motschulsky. Erwin 1965:4.

Brachynus cognatus Chaudoir, 1876:74. Lectotype, here selected, a female, MHNP, labelled "cognatus m. Mexico" and "Orizaba" on green paper and "Ex Museo Chaudoir" on white paper. _Type locality_.—Orizaba, Mexico, as given on Chaudoir's label. NEW SYNONYMY.

Brachinus cancellatus Bates, 1891:269. Lectotype, here selected, a male, BMNH, labelled "Chihuahua City, Mexico," and "Höge." It is placed in the series labelled "B. cognatus Chaudoir." _Type locality_.—Chihuahua City, Mexico, as originally given by Bates. NEW SYNONYMY.

Diagnostic combination.—The lack of elytral pubescence immediately separates members of this species from all others

of the genus.

Description.—Small-sized beetles, 5.0 to 8.0 mm.

Color. Ferrugineous, except antennal article 4 may be infuscated. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows rugose and punctate. Surface of pronotum microrugose, with an occasional setiferous puncture, but usually glabrous.

Head. Frontal furrows moderately impressed. Antennal scape cylindrical. Ligula with sclerotized center area ellipsoid-convex with two paramedian rows of three setae per row. Mentum (fig. 18) sulcate medially, sulcus surrounded by setae. Submentum (fig. 18) shortened and with accessory setae.

Prothorax. Pronotum (fig. 174) convex, flattened along center line, sides slightly reflexed. Proepipleura and proepisterna usually glabrous. Anterior tibia with anterior edge strigose.

Pterothorax. Elytra short and convex with quite arcuate sides. Humeral angles square, costae elevated and smooth, depressions between costae slightly rugose. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 186, 187, 188). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend short. Median lobe slightly swollen medially, just before bend. Apex of shaft narrowed, blunt and deflected ventrally. Ligule short, broad, and truncate. Virga (figs. 186, 187). Female (fig. 196). Stylus short, narrow, tapering to acute apex.

Variation.—Besides the intrapopulational variation in body

size and shape of the pronotum, these beetles are rather constant throughout the range of the species.

Flight.—These beetles have been recorded coming to lights in Mexico.

Etymology.—Latin, *costa* = rib; *pennis* = wing; referring to the raised costae of the elytra.

Collecting notes.—I collected these beetles along an intermittent stream on the eastern slope of the Mount Hamilton Range near San Jose, California. The sides of the stream were lined with specimens of *Salix* and *Quercus* species and an occasional specimen of *Platanus* species. The beetles were beneath small and large stones near the water.

Life history.—Members of this species have been collected in all months, except January. Teneral adults were collected in March in Oaxaca and in July in California.

Distribution.—(Fig. 197). The range of this species extends from Utah and northern California to Chiapas, Mexico, and east to the Big Bend area of Texas. The specimens labelled "Arkansas," "Kansas," and "Yukon," must be suspected as being mislabelled. I have seen 1,810 specimens from the following localities:

CANADA

YUKON: (No locality given) ISNH, WSUP.

CENTRAL AMERICA

GUATEMALA: (Agua Caliente) MCZ; (Los Amates) MCZ.

MEXICO

BAJA CALIFORNIA: (Hamilton Ranch) CAS; (San Vicente) CAS; (Tijuana) CNHM. DURANGO: (Durango City) MCZ; (12.2 miles south of El Banco)

UASM. JALISCO: (Atenquique) CAS. OAXACA: (25.0 miles south of Mitla) ISUA; (Oaxaca City) CAS; (22.5 miles west of Oaxaca) UASM; (Paderon, Rio Tehuantepec) AMNH; (Rio Atoyac, near Juchatengo) UASM; (Rio Malatengo, 11.1 miles north of Matias Romero) UASM; (72.5 miles south of Valle Nacional) UASM. PUEBLA: (near Petlalcingo) UASM; (Puente Tepexco, near Tepexco) UASM. SAN LUIS POTOSI: (El Pujal) CPBo; (2.7 miles west of Santa Catarina) UASM; (Tamazunchale) AMNH, CAS, MCZ. SINALOA: (Rosario) CAS. SONORA: (7.2 miles southeast of Alamos) GRNo; (Hermosillo) CAS; (Sonoyta) AMNH. VERACRUZ: (Fortin de las Flores) UASM, CPBo; (Orizaba) UNLN. ZACATECAS: (Juchipila 0.9 miles north of Jalpa) UASM.

UNITED STATES

ARIZONA: Cochise County (Chiricahua Mountains) CAS, (17.0 miles east of Douglas) UCR, (Dragoon Mountains, Texas Pass) MCZ, (Portal) GRNo, RCGr, (San Pedro River, near Palominas) UASM, (San Pedro River, east of Sierra Vista) UATA, (Tombstone) SDNHM; Coconino County (Grand Canyon, mile 52.0) UATA, (Grand Canyon, Havasupai Indian Reservation) UMSP, (Oak Creek Canyon, near Flagstaff) CAS; Gila County (Carrizo Creek, near Carrizo) DRWh, (Gila Valley) CAS, (near Globe) UATA, (Payson) UATA, (Pinal Mountains) SDNHM, (San Carlos Lake) UATA, (Winkelman) UATA; Graham County (Aravaipa) CAS, (Aravaipa Creek, between Klondyke and Aravaipa) DRWh, (Geronimo) CAS, UATA; Maricopa County (Phoenix) CNC, MCZ, OUCO; Navajo County (8-15.0 miles northeast of Whiteriver) AMNH; Pima County (Saint Xavier Mountains) CAS, (Tucson) AMNH, CAS, MCZ, USNM; Pinal County (Aravaipa Canyon) CUNY, (Florence) ANSP, CMPP, (Sycamore Camp, 9.0 miles north-west of Payson) CAS; Santa Cruz County (Lewis Springs, San Pedro

River) UASM, (Patagonia) CAS, CNHM, CUNY, UATA, UCD, UCR, (5.0 miles southwest of Patagonia) AMNH, (Peña Blanca) UASM; Yavapai County (Bumble Bee) CAS, (Camp Verde) CAS, (Congress) UATA, (Prescott) AMNH, MCZ, (Verde River) USNM, (5.0 miles north of Wickenburg) UMAH; Yuma County (Fort Yuma) USNM, (Yuma) LACM, USNM; County unknown (Gila River) CNC. ARKANSAS: Hempstead County (Hope) MCZ. CALIFORNIA: Alameda County (Oakland Hills) CAS; Calaveras County (Mokelumne Hill) CAS; Fresno County (Camp Greeley) CAS, (Le Fevre Creek) CAS, (Sanger) CAS, (Trimmer) UMSP; Humboldt County (Garberville) CAS, LACM; Imperial County MCZ, (Carrizo) SDNHM, (Castiac) UIMI; Kern County AMNH, USNM, (Caliente) BMNH; Los Angeles County PSUU (Big Dalton Dam) UCD, (Big Tujunga) LACM, (Burbank) CNHM, ISNH, (Frenchman's Flats) GRNo, LACM, (Lake Arrowhead) CAS, (Los Angeles) CNHM, UATA, UNLN, USNM, (Los Angeles River) LACM, UCR, (Newhall) CUNY, USNM, (Pasadena) ANSP, CMPP, CNHM, CUNY, LACM, MCZ, (Rio Hondo) LACM, (Tujunga Pass) UCD, (San Francisquito Canyon) LACM, UCD, (San Gabriel Canyon) GRNo, TCBa, (San Gabriel Mountains, Camp Bonita) LACM, (Santa Monica) UMSP; Madera County (Coursegold) CAS, UIMI; Mendocino County (Navarro River 2.0 miles northwest of Philo) CAS, (Ukiah) VVBa; Monterey County (Salinas) USNM, (Stone Canyon) CAS; Orange County (Costa Mesa) UCD, UCR, (Huntington Beach) USNM, (Olive) TAMU, (Santa Ana) CMPP, MCZ, TAMU; Placer County (No locality given) CAS; Riverside County (Corona) USNM, (Elsinore) CMPP, (Elsinore Lake) CAS, (Gilman Hot Springs) UCD, (Hemet) VVBa, (Palm Canyon) LACM, (Riverside) ANSP, CAS, CUNY, UMAH, USNM, (Simond's) LACM, (Temecula) CAS, (White Water Canyon) SJSC, UCR; Sacramento County (Folsom) USNM; San Bernardino County OUCO, (Afton Canyon) USNM, (San Bernardino) CAS, ISNH, (Cajon)

CNHM, (Cajon Pass) UCD, (Cajon Wash) LACM, (Colton) CAS, CUNY, MCZ, UATA, UCR, UMAH, (Redlands) MCZ; San Diego County CCha, UMAH, (Banner) SDNHM, (Dehesa) SDNHM, (Descanso) CAS, (El Monte Oaks) SDNHM, (Mission Dam) SDNHM, (Mission Valley) SDNHM, (Mountains of San Diego County) USNM, (Oceanside) CAS, (Pine Valley) CNC, MCZ, SDNHM, UMSP, (Poway) CAS, USNM, (Rincoln) SDNHM, (San Diego) ANSP, CNHM, CUNY, MCZ, SDNHM, USNM, (San Pasqual) UCR, (Valley Center) SDNHM, (Warner's Hot Springs) PUM, (Warner's Ranch) SDNHM; San Francisco County (San Francisco) CMPP; San Luis Obispo County (Arroyo Grande) CAS; Santa Barbara County (Santa Barbara) MCZ, (Santa Cruz Island) CAS, (Santa Cruz Island, Christie Beach) TLEr, (Santa Cruz Island, Christie Ranch) UCR, (Shephard's Inn) CAS; Santa Clara County (Adobe Creek) CAS; Sonoma County (Dry Creek, 9.0 miles northwest of Healdsburg) SJSC, (Duncan Mills) CAS, (2.0 miles east of Healdsburg) CAS, (Rio Nido) CAS; Stanislaus County (15.0 miles west of Patterson) TLEr; Tehama County (western hills of Tehama County) CAS; Tulare County (Sequoia National Park) VVBa; Ventura County (Santa Paula) ANSP, CAS; Yolo County (Davis) UCD; Counties unknown (Aliso Creek) UWSW, (Colorado Desert) MCZ, (Sylvania) MCZ. KANSAS: Douglas County (No locality given) CUNY. NEW MEXICO: Catron County (near Aragon) AMNH, (San Francisco Creek, 26.1 miles north of Glenwood) DRWh, UASM; Grant County (18.0 miles north of Mimbres, Roberts Lake) TLEr. TEXAS: Brewster County (Big Bend National Park, Hot Springs) CNC, (Rio Grande) CAS. UTAH: Garfield County (Boulder) ISUA; Grand County OUCO, (Moab) CAS, Washington County SDNHM, (3.0 miles south of Gunlock) GRNo, (Saint George) AMNH, KSU, MCZ, (Santa Clara Creek) UCD, (Zion National Park) CAS.

4.59 The alternans group

This small group of three species is characterized by the tripartite virga of the endophallus with elongate median apex, and plurisetose ligula. The group is divided into two subgroups.

4.591 The alternans subgroup

This subgroup is characterized by the accessory setae of the mentum and submentum, and the narrow ligule of the male median lobe. Two closely related species, *B. alternans* Dejean and *B. viridipennis* Dejean, are included.

4.5911 *Brachinus alternans* Dejean

(Figs. 172, 173, 189, 190, 191, 194, 201)

Brachinus alternans Dejean, 1825:316. Lectotype, here selected, a female, MHNP, labelled "alternans m. in Amer. bor." on green paper, "Georgia" on green paper, "D. Escheri" on green paper, and "Ex Museo Chaudoir" on white paper. *Type locality*.—Georgia, as originally given by Dejean.

Brachinus librator Dejean, 1831:425. Lectotype, here selected, a male, MHNP, labelled "librator m. in Amer. bor." and "LeConte" on green paper, and "Ex Museo Chaudoir" on white paper. *Type locality*.—North America, as originally given by Dejean. NEW SYNONYMY.

Brachinus deyrollei Laferte, 1841:42. Lectotype, here selected, a male, MHNP, labelled "Missouri, Reiche" and "Ex Museo Chaudoir." *Type locality*.—Missouri, as given on the label. NEW SYNONYMY.

Brachinus _strennus_ LeConte, 1844:48. Lectotype, here selected, a female, MCZ red type label number 5844. Further labelled with an orange disc and "76." _Type_ _locality_.—Georgia, as originally given by LeConte. NEW SYNONYMY.

Brachinus _tormentarius_ LeConte, 1848:200. Lectotype, here selected, a female, MCZ red type label number 5845. Further labelled with a yellow disc and "77." _Type_ _locality_.—Western States, as originally given by LeConte. NEW SYNONYMY.

Brachinus _distinguendus_ Chaudoir, 1868:287. Lectotype, here selected, a male, MHNP, labelled "fumans h. in Amer. bor." on green paper, and "Ex Museo Chaudoir" on white paper. _Type_ _locality_.—United States, as originally given by Chaudoir. NEW SYNONYMY.

Diagnostic _combination_.—The diagnostic characteristics are given in the key.

Description.—Large-sized beetles, 11.5 to 16.5 mm.

Color. Various. Elytra blue, rarely with greenish luster.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows, head behind eyes, and surface of pronotum moderately punctate, punctures moderately impressed.

Head. Frontal furrows moderately impressed. Antennal scape robust, widened apically. Ligula with sclerotized center area ellipsoid-convex, plurisetose. Mentum and submentum with numerous accessory setae.

Prothorax. Pronotum (fig. 172) convex, flattened along center line, sides barely reflexed. Surface with punctures moderately impressed. Proepipleura and proepisterna pubescent. Anterior tibia with anterior margin weakly strigose.

Pterothorax. Elytra elongate, broad, moderately costate. Humeral angle square. Costae smooth, glabrous, depressions between costae pubescent. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 189, 190, 191). Median lobe with plane of shaft hardly rotated from plane of basal bend. Basal bend short. Median lobe arcuate, slightly swollen at middle, apex variable. Ligule short, narrow and truncate. Virga (figs. 189, 190). Female (fig. 194). Stylus broad, arcuate, and elongate, apex narrowly rounded.

Variation.—The members of this species are among the most variable of the genus in North America. Intrapopulational variation in the shape of the pronotum is illustrated in figures 172 and 173. The color of the venter involves four combinations of ferrugineous and infuscated areas, as follows: sides of abdomen infuscated, remainder ferrugineous; the preceding, plus the mesepisterna and metepisterna, infuscated; both the preceding, plus the metasternum at sides, infuscated; and finally, the preceding, plus all the abdomen, infuscated (except ferrugineous dimples). The pale condition is commonest in the midwest, and rare toward the south and east. However, one or more of these conditions is common to single populations. Variation occurs in the apex of the shaft of the male genitalia also. The bent or unbent condition is independent of the color cline described above, and (as color variation) is common to local populations.

Flight.—C. W. O'Brien has recorded these beetles flying to "blacklights" in Florida.

Etymology.—Latin, alternus = alternate; referring to the costate elytra.

Life history.—Members of this species have been collected during all months of the year. Teneral adults were collected in April in Illinois, in August in Tennessee, in September in Nebraska and Illinois, and in November in North Carolina. Overwintering probably takes place as an adult.

Distribution.—(Fig. 201). The range of this species extends from New Mexico north to Minnesota, east to Connecticut, and south to the Florida Keys. I have seen 1,141 specimens from the following localities:

UNITED STATES

ALABAMA: Clarke County (Salt Mountain, 6.0 miles south of Jackson) UMAH; Lee County (Auburn) AUAA; Mobile County (Magazine Point) CAS, (Mobile) ANSP, CAS, MCZ, (Mount Vernon) AUAA, OUCO; Tuscaloosa County (Tuscaloosa) UASM. ARKANSAS: (No locality given) AMNH; Conway County (No locality given) UAFA; Jefferson County (Pine Bluff) ISNH; Lawrence County (Imboden) CAS, USNM; Mississippi County UAFA, (Osceola) UMAH. CONNECTICUT: New Haven County (Hamden) CAS. DISTRICT OF COLUMBIA: (Washington) UMSP. FLORIDA: Alachua County (Gainesville) FDAG, RFre, UMAH, (Grant's Cave) FDAG, (Poe Springs) UMAH; Baker County (Glen Saint Mary) FDAG; Brevard County (Indian River) ISNH, USNM; Broward County (Fort Lauderdale) UMAH; Charlotte County (Punta Gorda) CNC, CNHM; Citrus County (No locality given) CAS; Collier County (Everglades) OUCO, UMAH, USNM; Dade County UATA, (18.0 miles northwest of Hialeah) TLEr, (Homestead) AMNH, FDAG, TLEr, (Long Pine Key) MCZ, (Miami) UCD, (Paradise Key) AMNH, CNC, USNM, (Royal

Palm State Park) AMNH, PUM, UCR, UMAH; Duval County (Arlington) AMNH, (Jacksonville) AMNH, ANSP, USNM; Glades County (Moore Haven) USNM, (Palmdale) AMNH; Hendry County (Clewiston) RCGr, (La Belle) PUM; Hernando County (Brooksville) CAS; Highlands County (Archbold Biology Station) CMPP, CUNY, PSUU, (Highlands Hammock State Park) TLEr, (4.5 miles west of Venus) TCBa; Hillsborough County (Plant City) UMAH, (Tampa) CAS; Jefferson County (Monticello) AMNH; Lake County UMAH, (Leesburg) CAS; Lee County (Fort Myers) PUM, (Sanibel Island) CAS; Leon County (Lake Jackson) UMAH; Levy County (No locality given) ANSP; Madison County (Greenville) FDAG; Manatee County (Oneco) UASM; Marion County (No locality given) MCZ; Orange County (Orlando) OUCO, (Winter Park) MCZ; Osceola County (Kissimmee) AMNH, ANSP, CUNY, PUM; Palm Beach County (Canal Point) CUNY, (Lake Worth) CMPP, (Stewart) UMAH; Pinellas County (Dunedin) CAS, PUM, UWMW, (Saint Petersburg) CAS, PUM; Putnam County (Crescent City) USNM, (Welaka) UMAH; Saint Johns County (Saint Augustine) AMNH, CAS; Sarasota County (Myakka State Park) CUNY, UASM, (Sarasota) PUM; Seminole County (Sanford) MCZ, PUM; Volusia County (Enterprise) ANSP, CAS, OUCO, USNM, (Ormond Beach) PUM; Counties unknown (Capron) USNM, (Cutier) USNM, (Detroit) USNM, (Hardkinsville) MCZ, (Lake Apopka) AMNH, (Lake Okeechobee) PUM, (Lake Poinsett) USNM, (Port Sewall) AMNH, (Sand Point) USNM. GEORGIA: Charlton County (Okefenokee Swamp, Billy Island) CUNY, USNM; Thomas County (Thomasville) AMNH, USNM. ILLINOIS: Alexander County (Olive Branch) CAS, CMPP, CNHM; Cook County (Chicago) CAS, (Palos Park) UMAH; Jackson County (Carbondale) ISNH; Johnson County (South of Vienna) RTBe; (Richland and Lawrence Counties (Wabash) MCZ; Saint Clair County (No locality

given) CAS, UWMW; Union County (Alto Pass) CNHM; Counties unknown (Fountain Bluff) ISNH, (Pike) ISNH. INDIANA: Knox County (No locality given) PUM; Perry County (No locality given) PUM; Posey County (Hovey Lake) CEWh, PUM, (Mount Vernon) CEWh; Spencer County (No locality given) CAS, PUM; Vigo County (No locality given) PUM. KANSAS: Coffey County (No locality given) ULLK; Douglas County (Baldwin) OSUC, (5.0 miles north of Baldwin City) RFre, (Lawrence) CAS, PUM, UCD, UMAH, USNM, (3.0 miles northwest of Lawrence)UNLN; Franklin County (No locality given) KSU; Montgomery County (Independence) CAS; Riley County (Manhattan) KSU; Shawnee County (Topeka) CMPP, KSU; County unknown (Fort Hays) MCZ. KENTUCKY: Bell County (Pineville) UAFA; Jefferson County (Louisville) UAFA; Jessamine County (Indian Falls) TCBa; Mercer County (Dix Dam) TCBa; Rockcastle County (Crooked Creek) TCBa. LOUISIANA: (No locality given) ISNH, UMSP; Cameron Parish USNM, (Grand Chenier) CNC; Iberia Parish (Avery Island) ANSP; Madison Parish (Tallulah) TAMU, UMAH; Natchitoches Parish (Natchitoches) UMAH; Orleans Parish (New Orleans) CAS, USNM, ZMLS; Ouachita Parish (Calhoun) UAFA; Plaquemines Parish (Nairn) MCZ; Vermilion Parish (Gueydan) USNM; Vernon Parish (Rosepine) UAFA. MARYLAND: Dorchester County (near Lloyds) USNM; Harford County (Edgewood) CUNY. MICHIGAN: Allegan County (Allegan) CAS. MINNESOTA: Olmsted County (No locality given) UMSP. MISSISSIPPI: Attala County (Cole Creek, Natchez Trace) RCGr; Carrol County (Avalon) UMAH; George County (Lucedale) CUNY; Greene County (Leakesville) CUNY; Hinds County (Jackson) UMAH; Lamar County (Lumberton) CUNY; Lauderdale County (Meridian) UMAH; Leflore County (Greenwood) UMAH; Perry County (New Augusta) CUNY;

Sharkey County (Rollingfork) USNM; Tunica County (Dundee) UMAH; Washington County (Leroy Percy State Park) RCGr; County unknown (Moon) AMNH. MISSOURI: Buchanan County (Saint Joseph) USNM; Marion County (Hannibal) CAS; Saint Charles County (Saint Charles) MCZ; Vernon County (Nevada area) TLEr; County unknown (Big Oak State Park) RTBe. NEBRASKA: Dakota County (South Sioux City) UNLN; Nemaha County (Peru) CNHM; Sarpy County (Bellevue, Childs' Point) CAS, UNLN. NEW JERSEY: Bergen County (Ramsey) USNM; Cape May County (Five Mile Beach) USNM; Gloucester County (Westville) MCZ; Ocean County (Lakehurst) AMNH; County unknown (Split Rock Lake) USNM. NEW YORK: New York County (New York City) MCZ; Westchester County (Peekskill) CAS, MCZ. NORTH CAROLINA: Catawba County (Newton) UCR; Darne County (Cape Hatteras) USNM; Duplin County (Wallace) UCR; Haywood County (Crestmont) UMAH; (Mount Sterling) CUNY; Robeson County (Boardman) USNM; Wake County (Raleigh) UCR, UNCR; County unknown (Beauford) MCZ. OHIO: Clinton County (No locality given) OUCO; Hamilton County (Cincinnati) UMAH; Scioto County (No locality given) OUCO. OKLAHOMA: Alfalfa County (No locality given) OSUS; Choctaw County (No locality given) OSUS, UONO; Cleveland County OUCO, UONO, (Norman) CAS; Dewey County (Seiling) OSUS; Le Flore County (Poteau) OSUS; McCurtain County RCGr, (Eagletown) OSUS, (Idabel) OSUS; Mazes County (No locality given) UONO; Nowata County (13.0 miles west of Vinita) RFre, UASM; Oklahoma County (Oklahoma) CEWh; Tillman County (No locality given) CAS; Tulsa County (Collinsville) CAS. PENNSYLVANIA: Allegheny County (Pittsburgh) CMPP. SOUTH CAROLINA: Florence County (Scranton) UMAH; Jasper County (Savannah River Refuge) UASM; Oconee County

(Clemson) UASM; Sumter County (Poinsett State Park) VMKi. TENNESSEE: Knox County (Knoxville) MCZ; Morgan County (Sunbright) CMPP; Obion County (Reelfoot Lake) UMAH; Overton County (Cleeks Mill) TCBa; Putnam County (Cookeville) TCBa; Sevier County (Great Smoky Mountains National Park) CMPP; Smith County (Peyton Creek) TCBa. TEXAS: Brazos County (bottoms) ISNH, (College Station) MCZ, TAMU; Cameron County (Brownsville) OUCO, (Brownsville, Esperanza Ranch) USNM; Colorado County (Columbus) MCZ, UMSP; Dallas County CAS, ISNH, (Dallas) CMPP, MCZ; Dimmit County (Currizo Springs) ISUA; El Paso County (El Paso) CMPP; Grayson County (Juniper Point, Lake Texoma, 12.0 miles north of Whitesboro) RCGr; Harris County (Houston) UCD, (Seabrook) CAS; Hunt County (Commerce) OUCO; Jeff Davis County (Davis Mountains) OUCO; Kendall County (Comfort) CMPP; Liberty County (Devers) UMAH; Runnels County (Ballinger) USNM; Travis County (S. F. Austin State Park) CNHM; Victoria County (Victoria) USNM; County unknown (Fuller) USNM. VIRGINIA: Alexandria County (No locality given) USNM; Fairfax County (Mount Vernon) USNM; Nansemond County (Cypress Chapel) ISUA; Norfork County (Dismal Swamp) AMNH, CAS, USNM; Spotsylvania County (Fredericksburg) CAS. WEST VIRGINIA: Berkeley County (Leetown) RTBe; Greenbrier County (While Sulphur Springs) MCZ.

4.5912 *Brachinus viridipennis* Dejean
(Figs. 179, 183, 184, 185, 193, 199)

Brachinus viridipennis Dejean, 1831:426. Lectotype, here selected, a female, MHNP, labelled "v. viridipennis m. in Amer. bor.," "LeConte" on green paper, and "Ex Museo Chaudoir" on white

paper. Type locality.—"l'Amerique septentrionale" as originally given by Dejean, but herewith restricted to Mobile, Alabama.

Brachinus viridis LeConte, 1844:49. Lectotype, here selected, a male, MCZ red type label number 5840. Further labelled with a gold disc and "85." Type locality.—Georgia, as originally given by LeConte. LeConte 1862:524.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Large-sized beetles, 8.9 to 15.0 mm.

Color. Antennal article 4, sides of mesosternum and metasternum, mesepisterna, metepisterna, and abdominal sterna and terga infuscated. Dorsal surface and epipleura of elytra greenish to bluish.

Microsculpture. As described for genus.

Macrosculpture. As in alternans.

Head. As in alternans.

Prothorax. As in alternans, except anterior tibia with anterior edge punctate, with punctures sometimes forming elongate grooves, but not strigae.

Pterothorax. Elytra elongate, narrow, weakly costate. Humeral angle sloped. Metasternum short, its length behind middle coxa less than diameter of middle coxa (fig. 26). Wings reduced outside stigma.

Abdomen. As described for genus.

Genitalia. Male (figs. 183, 184, 185). Median lobe with plane of shaft rotated slightly from plane of basal bend. Basal bend short. Median lobe straight, swollen medially, apex narrow, elongate.

Ligule long, narrow, slightly widened at apex. Virga (figs. 183, 184). Female (Fig. 193). Stylus long, narrow, arcuate, narrowly rounded apically.

Variation.—Besides the intrapopulational variation in body size and shape of the pronotum, these beetles may have greenish or bluish colored elytra. Those with bluish elytra are few and occur among the greenish populations.

Flight.—The flight of these beetles has never been recorded, and it is probable that they cannot fly.

Etymology.—Latin, *viridis* = green; *pennis* = wing; referring to the greenish elytra of these beetles.

Life history.—Members of this species have been collected in all months, except January, May, and August, but no teneral adults were seen.

Distribution.—(Fig. 199). The range of this species extends from eastern Texas to Florida. I have seen 81 specimens from the following localities:

UNITED STATES

ALABAMA: Clay County (Ashland) AUAA; Mobile County (Alabama Port) CAS, (Coden) AMNH, (Mobile) ANSP, CAS, CUNY, OUCO, UASM, UMAH, USNM. ARKANSAS: Hempstead County (Hope) MCZ. FLORIDA: Baker County (Glen Saint Mary) FDAG; Duval County (Jacksonville) MCZ, USNM. GEORGIA: Chatham County (Savannah) CAS; County unknown (Fort Stewart) TLEr. SOUTH CAROLINA: Beaufort County (Hardeeville) UMAH. TEXAS: Colorado County (Rock Island, Skull Creek) UMSP.

4.592 The *rugipennis* subgroup

This subgroup is characterized by the wide ligule of the male genitalia, absence of accessory setae, and narrow prothorax. One species *B. rugipennis* Chaudoir, is included.

4.5921 *Brachinus rugipennis* Chaudoir

(Figs. 171, 180, 181, 182, 192, 200)

Brachynus rugipennis Chaudoir, 1868:297. Lectotype, here selected, a female, MHNP, labelled "Etas Unis Guex" on the box and "Ex Museo Chaudoir" on the specimen. *Type locality*.—United States, as given originally by Chaudoir's label, but herewith restricted to Texas.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Small to medium-sized beetles, 7.1 to 9.4 mm.

Color. Antennal articles 3 and 4, abdominal terga, and sides of abdominal sterna infuscated, the latter two usually very dark. Remainder of abdominal sterna and usually some of metepisterna lightly infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and surface of pronotum punctate, punctures shallowly impressed.

Head. Frontal furrows shallowly impressed. Antennal scape narrow, almost cylindrical. Ligula as in *alternans*. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 171) slightly convex, flattened along center line, sides narrowly reflexed. Surface with punctures moderately impressed. Proepipleura and proepisterna pubescent anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior surface strigose.

Pterothorax. Elytra elongate, narrow, weakly costate. Humeral

angle slightly sloped. Costae rugose, as well as depressions between costae.

Abdomen. As described for genus.

Genitalia. Male (figs. 180, 181, 182). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend moderately long. Median lobe arcuate, broadened to apex, and with apex broadly rounded. Ligule short, widened apically, truncate. Virga (figs. 180, 181). Female (fig. 192). Stylus short, narrow, parallel-sided, narrowly rounded apically.

Variation.—This species is rather constant throughout its range, even in body size.

Flight.—These beetles have been collected repeatedly at lights throughout the range of the species.

Etymology.—Latin, ruga = wrinkle or fold; pennis = wing; referring to the costate elytra.

Collecting notes.—C. Armin collected these beetles along margins of lakes and irrigation ditches, and at the edges of small streams in Colorado.

Life history.—Members of this species have been collected from December to July, and in October. Teneral adults have been collected in March and December in Florida, and in October in Massachusetts.

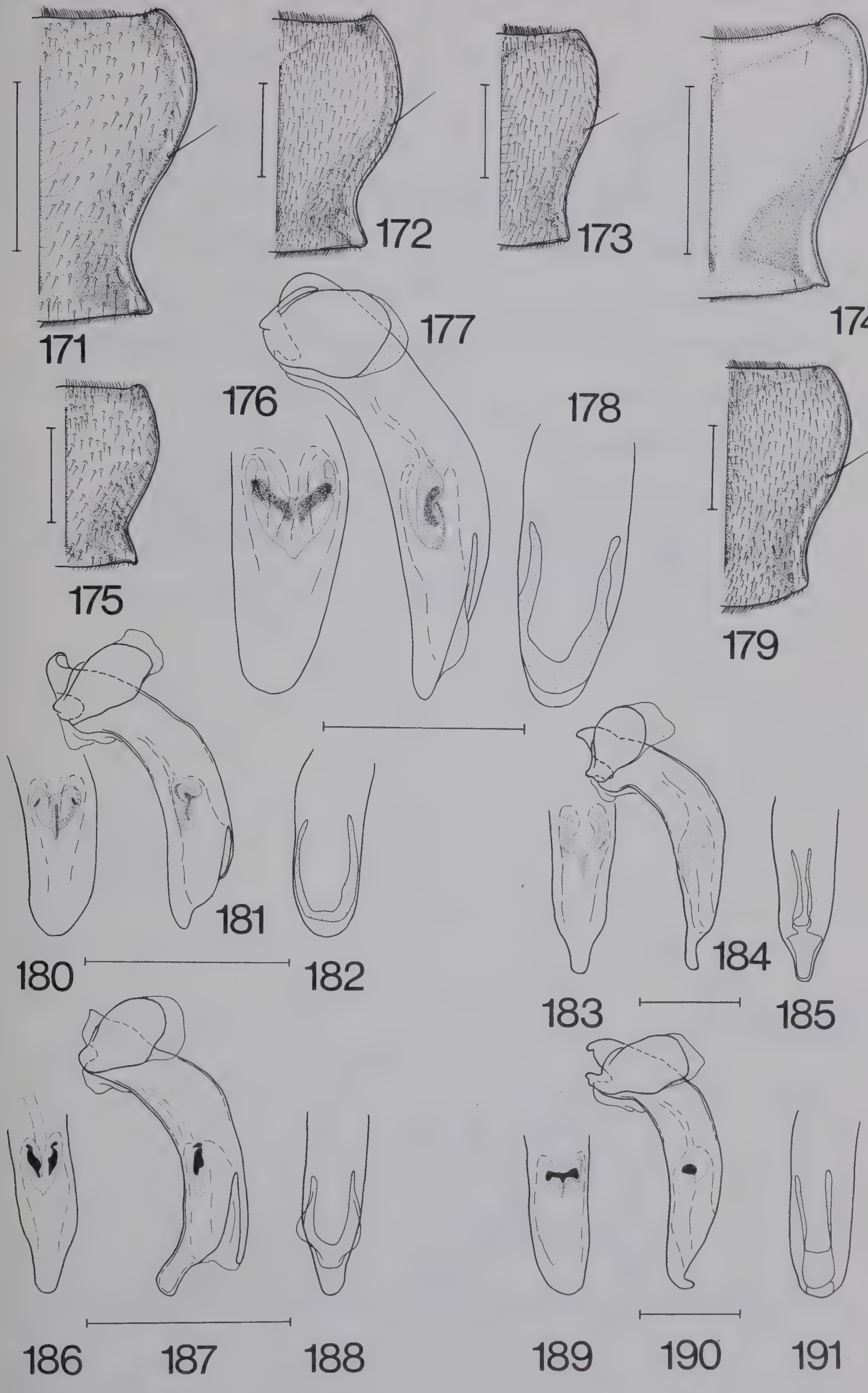
Distribution.—(Fig. 200). The range of this species extends from western Colorado to Massachusetts, and south to Florida. There appears to be discontinuity between the New England populations and the Floridian one, and between these populations and those west of the Mississippi. I have seen 327 specimens from the following localities.

UNITED STATES

ARKANSAS: Garland County (Hot Springs National Park) SJSC; Hempstead County (Hope) CUNY, MCZ, UMAH; Pike County (Delight) CMPP; Washington County (No locality given) UAFA; White County (Searcy) UWSW. COLORADO: Boulder County (El Dorado Springs) CArm, (Teller Lake) CArm; Montrose County (Montrose) MCZ. FLORIDA: Alachua County (Gainesville) UMAH; Brevard County (Eau Gallie) MCZ, (Indian River) USNM; Charlotte County (Charlotte Harbor) AMNH, (Punta Gorda) AMNH, UMAH; Collier County (Collier Seminole State Park) TLEr, (Naples) CUNY; Dade County (Royal Palm State Park) PUM; Hendry County (La Belle) OUCO; Highlands County (Archbold Biology Station) CUNY, PSUU, (Childs) RCGr, (Lake Placid) AMNH; Hillsborough County (Tampa) USNM; Lee County (Fort Myers) CNC; Lake County USNM, (Fruitland Park) UMAH; Manatee County (Bradenton) CAS, (Oneco) UASM; Marion County MCZ (Silver Springs) CAS; Orange County (Orlando) MCZ, (Pinecastle) FDAG, (Winter Park) MCZ; Osceola County (Kissimmee) AMNH; Pinellas County (Dunedin) CAS, PUM, TAMU, (Tarpon Springs) CNC; Sarasota County (Englewood) AMNH, (Sarasota) PUM; Taylor County (Steinhatchee) USNM; Volusia County (Enterprise) CAS, USNM; Counties unknown (Port Sewall) AMNH, (Suwannee River) CAS. GEORGIA: Lowndes County (Valdosta) UMAH. KANSAS: Stafford County (Salt Flats Area) UASM. MASSACHUSETTS: Hampden County (Chicopee) KSU, MCZ, (Wilbraham) MCZ; Plymouth County (Plymouth) AUAA. OKLAHOMA: Marshall County (Lake Texoma, Willis) RCGr, (Madill) RCGr. NEBRASKA: Cherry County (Hackberry Lake) UNLN. NEW JERSEY: Cape May County (Seven Mile Beach) OUCO; Mercer County (Trenton) CAS; Warren County (Phillipsburg) CAS; County unknown (Anglesea) CAS. NEW MEXICO: Bernalillo County (Albuquerque) ANSP, CAS, MCZ, USNM; Sandoval County (Los Alamos) CNC; Taos County (Rio

Grande River, near Taos) CAS. PENNSYLVANIA: Montgomery County (Arcola) ANSP; Montour County (Danville) CAS; North hampton County (Easton) CAS, (Watergap) AMNH, USNM. TENNESSEE: Lake County (Parnell Point) RTBe. TEXAS: Anderson County (Elkhart) TAMU; Blanco County (2.0 miles south of Round Mountain) UASM; Brazos County (College Station) MCZ, TAMU; Dallas County (Dallas) MCZ, UASM; Deaf Smith County (Hereford) TAMU; Montgomery County (Willis) USNM; Nueces County (Corpus Christi) MCZ; County unknown (Bathage) CAS. VIRGINIA: (No locality given) UMSP. WYOMING: (Western Wyoming) USNM.

Figs. 171-175, 179. Pronotum, right half, dorsal aspect. 171. *Brachinus rugipennis* Chaudoir, Highlands County, Florida. 172. *Brachinus alternans* Dejean, Dallas County, Texas. 173. Same, Dallas County, Texas. 174. *Brachinus costipennis* Motschulsky, 12.2 miles south of El Banco, Durango, Mexico. 175. *Brachinus kansanus* LeConte, Scandia, Kansas. 179. *Brachinus viridipennis* Dejean, Mobile, Alabama. Figs. 176-178, 180-191. Male genitalia. 176. *Brachinus kansanus* LeConte, Scandia, Kansas, ventral aspect. 177. Lateral aspect of same. 178. Dorsal aspect of same. 180. *Brachinus rugipennis* Chaudoir, Archbold Research Station, Florida, ventral aspect. 181. Lateral aspect of same. 182. Dorsal aspect of same. 183. *Brachinus viridipennis* Dejean, Mobile, Alabama, ventral aspect. 184. Lateral aspect of same. 185. Dorsal aspect of same. 186. *Brachinus costipennis* Motschulsky, 12.2 miles south of El Banco, Durango, Mexico, ventral aspect. 187. Lateral aspect of same. 188. Dorsal aspect of same. 189. *Brachinus alternans* Dejean, Okefenokee Swamp, Georgia, ventral aspect. 190. Lateral aspect of same. 191. Dorsal aspect of same. Accompanying scale lines equal 1.0 mm.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Figs. 192-196. Right stylus of female ovipositor, ventral aspect. 192. Brachinus rugipennis Chaudoir, Hope, Arkansas. 193. Brachinus viridipennis Dejean, Mobile, Alabama. 194. Brachinus alternans Dejean, Seabrook, Texas. 195. Brachinus kansanus LeConte, Scandia, Kansas. 196. Brachinus costipennis Motschulsky, 26.1 miles north of Glenwood, New Mexico. Figs. 197-201. Geographical distribution maps. 197. Brachinus costipennis Motschulsky. 198. Brachinus kansanus LeConte. 199. Brachinus viridipennis Dejean. 200. Brachinus rugipennis Chaudoir. 201. Brachinus alternans Dejean. Accompanying scale line equals 1.0 mm.

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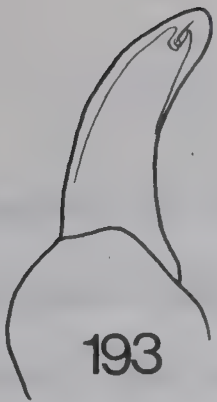

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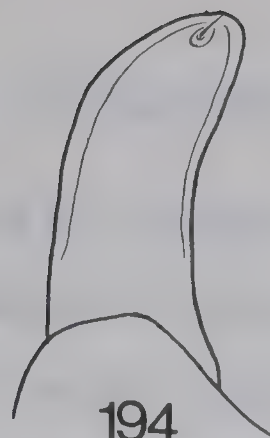

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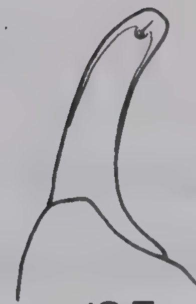

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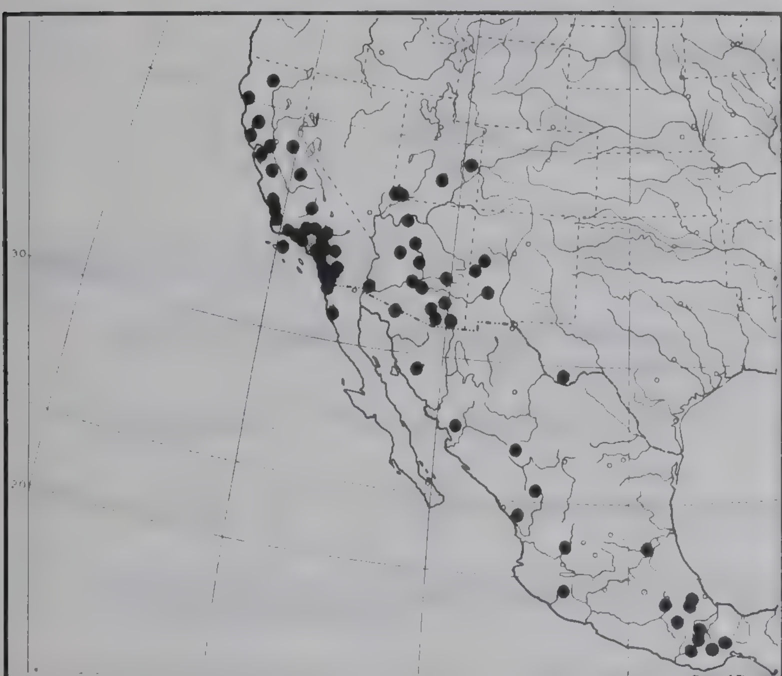

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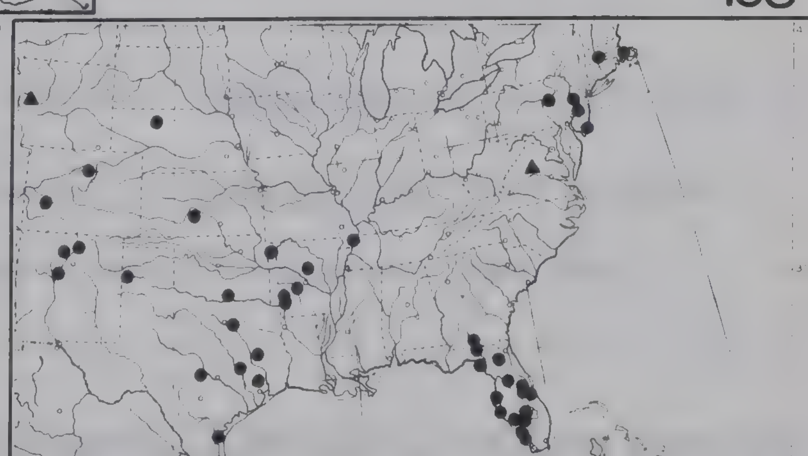

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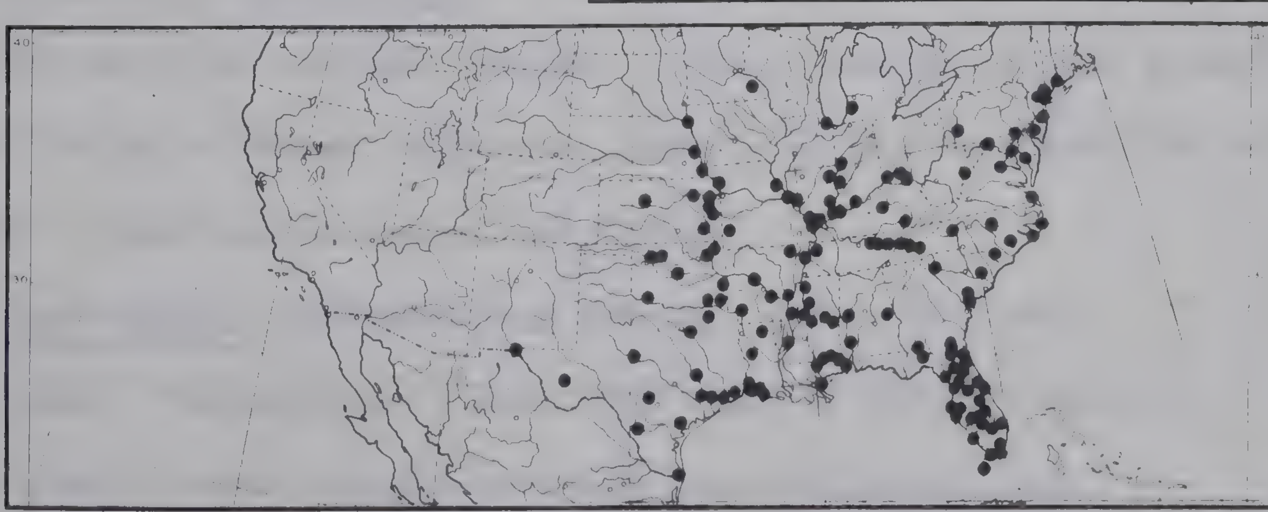


201

4.60 The *hirsutus* group

The members of this group are characterized by the form of the virga, compressed median lobe with a ventral sulcus, lack of lateral pronotal setae, and strongly costate elytra. Two species, *B. hirsutus* Bates and *B. pallidus* Erwin, are included.

4.6001 *Brachinus hirsutus* Bates
(Figs. 205, 212, 213, 214, 220, 224)

Brachinus hirsutus Bates, 1884:295. Lectotype, here selected, a male, BMNH, labelled "Pinos Altos, Chihuahua, Mexico, Buchan-Hepburn," "B. C. A. Col. I. 1. Brachinus hirsutus Bates," "Type, H. T." and "Brachinus hirsutus Bates" (handwritten).

Type locality.—Pinos Altos, Chihuahua, as originally given by Bates.

Brachinus puncticollis LeConte, 1858:28. NOMEN NUDUM. Erwin, 1965:13.

Notes.—In 1965 I wrongly placed *B. puncticollis* as a synonym of *B. tschernikhi* Mannerheim. After seeing LeConte's specimen, I now place the name here.

Diagnostic combination.—The densely pubescent cordiform pronotum, together with the strongly costate elytra, lack of lateral pronotal setae, and pale venter, separates members of this species from any others in American Southwest and Mexico.

Description.—Medium-sized beetles, 7.6 to 10.3 mm.

Color. Ferrugineous, sometimes sides of abdomen slightly infuscated. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows, head behind eyes, and surface of

pronotum densely punctate and rugose. Punctures moderately impressed.

Head. Frontal furrows moderately impressed. Antennal scape robust, widest at middle. Ligula with sclerotized center area ellipsoid-convex with two lateral rows of three setae per row. Mentum and submentum with accessory setae.

Prothorax. Pronotum (fig. 205) slightly convex, flattened along center line, sides moderately reflexed. Lateral setae absent. Proepipleura and proepisterna totally pubescent. Anterior tibia with anterior surface strigose.

Pterothorax. Elytra moderately long, narrow, strongly costate. Humeral angle square. Costae smooth, glabrous, depressions pubescent. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 212, 213, 214). Median lobe with plane of shaft rotated slightly from plane of basal bend. Basal bend long. Median lobe nearly straight, swollen just before compressed shaft. Apex of shaft narrow and acute, ventral surface sulcate. Ligule short, narrow, truncate. Virga (figs. 212, 213). Female (fig. 224). Stylus short, parallel-sided, rounded apically.

Variation.—The shape of the pronotum is much more constant in the members of this species than in other North and Middle American species. Intrapopulational variation does occur in the total size and in the color of the elytra (blue to bluish green).

Flight.—The flight of these beetles has been recorded by G. R. Noonan in Upper Sabino Canyon, Arizona.

Etymology.—Latin, hirsutus = hair; referring to the dense pubescence of the pronotum of these beetles.

Collecting notes.--G. E. Ball and I collected these beetles in coarse gravel at the edges of an intermittent stream near El Banco, Durango, Mexico.

Life history.--Members of this species have been collected in all months of the year except February and November. Many teneral adults have been collected in June and July in Arizona, and in January in Jalisco, Mexico. The life cycle is probably much the same as in *B. pallidus* (Erwin, 1967).

Distribution.--(Fig. 220). The range of this species extends from southern Utah to the southern edge of the Mexican Highplain. I have seen 456 specimens from the following localities:

MEXICO

DURANGO: (12.2 miles south of El Banco) UASM; (Nombre de Dios) AMNH; (Rio Chico, 15.7 miles west of Durango) UASM; (Rio Florido, near Las Nieves) UASM; (Rio Nazas, near Rodeo) UASM. HIDALGO: (Rio Tula, near Tasquillo) UASM. JALISCO (0.4 miles west of Coculo) UASM. SAN LUIS POTOSI: (Puente La Parada, 7.5 miles northwest of Mexquitic) UASM; (2.7 miles west of Santa Catarina) UASM. SONORA: (10.0 miles south of Alamos) UCD; (Sonoyta) AMNH. ZACATECAS: (Rio Juchipila, 0.9 miles north of Jalpa) UASM; (1.3 miles southeast of Sain Alto) UASM.

UNITED STATES

ARIZONA: Cochise County (Chiricahua Mountains) USNM, (14.0 miles northeast of Douglas) UCR, (Bear Creek, Montezuma Pass, Huachuca Mountains) CNC, (Portal) RCGr, (San Pedro River, east of Sierra Vista) UATA, (San Pedro River, 10.0 miles east of Sierra Vista) OSUC, (Tombstone) SDNHM; Coconino County (Bill Williams Fork) MCZ, (Grand

Canyon, mile 116.5) UATA; Gila County (East Verde River, 6.0 miles north of Payson) LACM, (Globe) KSU, (Payson) UATA, (Sierra Ancha Mountains) UMAH; Graham County (Aravaipa Creek, between Klondyke and Aravaipa) DRWh, (San Carlos Reservoir) UATA; Maricopa County (Phoenix) CNHM, MCZ, OUCO, UATA, (Wickenburg) RCGr; Mohave County (Beaver Dam) LACM, (16.0 miles north of Wikieup) LACM; Pima County (Cienega Creek, Pantano) CUNY, (Organ Pipe Cactus National Monument, Quito Baquito) GRNo, (Redington) UATA, (Sabino Canyon) AMNH, (Upper Sabino Canyon) GRNo, (Saint Xavier Mountains) CAS, (Santa Catalina Mountains) CAS, USNM, (Santa Catalina Mountains, Bear Canyon) CAS, UATA, (Tucson) AMNH, CAS, CUNY, MCZ, UMAH, USNM; Pinal County (Aravaipa) CUNY, (Sycamore Camp, 9.0 miles northwest of Payson) CAS, (near Sombrero Butte) USNM; Santa Cruz County (Bear Canyon Bridge, Lochiel-Bisbee Road) CAS, (Canelo Hills) UATA, (Nogales) CAS, USNM, (Patagonia) CNHM, CUNY, UATA, UCD, UCR, (Peña Blanca Lake, 16.0 miles northwest of Nogales) OSUC, (Santa Cruz River, near Nogales) CAS, (Yanks Spring, 4.0 miles southeast of Ruby) AMNH; Yavapai County AMNH (Bumble Bee) CAS, (Camp Verde) CAS, PSUU, (29.0 miles northwest of Congress) UATA, (Mayer) GRNo, (Prescott) CAS; Counties unknown (Hot Springs) CAS, (Palmerlee) CMPP, (Superstition Mountains) UATA. NEW MEXICO: Catron County (Glenwood) DRWh, (San Francisco Creek, 26.1 miles north of Glenwood) UASM; Grant County (near Gila) UASM. TEXAS: Jeff Davis County (Davis Mountains) CAS, UCD, USNM, (Fort Davis) AMNH, CNC, (6-10.0 miles west of Fort Davis) UASM, (Limpia Canyon) CNHM, DRWh, TLEr, SJSC, UASM; Reeves County (Balmorhea Lake) UASM; Presidio County (Presidio) TAMU. UTAH: Washington County (3.0 miles south of Gunlock) GRNo, (Saint George) USNM, (Santa Clara) UWSW.

4.6002 Brachinus pallidus Erwin

(Figs. 204, 215, 216, 217, 218, 222)

Brachinus pallidus Erwin, 1965:8. The holotype male and allotype female are in CAS. *Type locality*.—Mad River, 5.0 miles east of Mad River Post Office, Trinity County, California.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 7.5 to 9.3 mm.

Color. As in *hirsutus*.

Microsculpture. As described for genus.

Macrosculpture. Head as in *hirsutus*, pronotum not as densely punctate.

Head. As in *hirsutus*, but ligula without constant setae.

Prothorax. As in *hirsutus*, but less densely setiferous. Pronotum (fig. 204).

Pterothorax. As in *hirsutus*, but only depressions 6, 7, and 8 pubescent, except in apical third.

Abdomen. As described for genus.

Genitalia. Male (figs. 215, 216, 217). As in *hirsutus*, except more compressed and without ventral sulcus. Virga (figs. 215, 216). Female (fig. 222). Stylus straighter than in *hirsutus*, more acute apically.

Variation.—The members of this species vary within local

populations in body size and the shape of the pronotum. Otherwise, they are quite constant throughout the range of the species.

Flight.—I have watched these beetles fly in captivity.

Etymology.—Latin, *pallidus* = pale; referring to the pale venter of these beetles.

Collecting notes.—These beetles occur along intermittent streams and permanent rivers in coarse gravel.

Life history.—See Section 5 and Erwin 1967.

Distribution.—(Fig. 218). The range of this species extends from Los Angeles County in southern California north to eastern Washington. I have seen 835 specimens from the following localities:

UNITED STATES

CALIFORNIA: Alameda County (Alameda Creek) CAS, (Arroyo Mocho) TLEr, (Berkeley) CUNY, (Livermore) CAS, (Los Moches Canyon, Livermore hills) CEWh, (Niles Canyon) ANSP, CAS, SDNHM, UASM, (Sunol) CAS; Amador County (5.0 miles west of Sutter Creek on Horse Creek) TLEr; Butte County (Oroville) CAS; Calaveras County (Mokelumne Hill) CAS, USNM; Contra Costa County (Marsh Creek) TLEr; Fresno County (Camp Greely) CAS, (Kings Canyon) CAS, (La Fevre Creek) ANSP, UASM; Glenn County (Elk Creek) CAS; Humboldt County AMNH, (6.0 miles east of Bridgeville) GRNo, (Eel River, Fernbridge) UASM, (Fort Seward) CAS, UIMI, (Garberville) CAS, UIMI, (5.0 miles south of Garberville) TLEr, (Schively) UCD; Lake County (Lower Lake) CAS, (Middletown) CAS, JSch, UIMI, (North Fork Cache Creek, Highway 20) UCD, (Putah Creek) CAS; Los Angeles County USNM, (Los Angeles) CNHM; Madera County (Coursegold) CAS, UIMI; Marin County USNM, (Fairfax) CUNY, (Point Reyes) CAS, UCD; Mariposa County (Jolon) CAS, (3.0 miles

southeast of Jolon) CAS; Mendocino County CNHM, (Eel River) CAS, (Long Valley Creek, 6.7 miles south of Laytonville) CAS, UWSW; Merced County (Merced Falls) UCD; Napa County CMPP, (Monticello) UCD, (Pope Valley) CAS, (Rutherford) TLEr, (Saint Helena) AMNH, ROM, (Saint Helena Creek) CAS, (10.0 miles east of Shell Peak) CAS; Placer County (Auburn) UCD; Sacramento County (Folsom) JSch; San Joaquin County (No locality given) SJSC; San Luis Obispo County (Atascadero) CAS, (Nacimiento River, Camp Roberts) PSUU, (Paso Robles Creek) CAS; Santa Clara County CNHM, (Arroyo Bayo) SJSC, (Gilroy Hot Springs) TLEr, (Hecker Pass) CAS, (Isabel Creek) TLEr, (Los Gatos) CAS, (Morgan Hill) SJSC, (Mount Hamilton) CAS, JSch, (San Jose) CAS, (Santa Clara) CAS, (Uvas Creek) TLEr; Santa Cruz County (Santa Cruz) USNM; Shasta County CNHM, (Anderson) CAS, (Redding) CAS, VVBa; Siskiyou County (Klamath River) USNM, (10.0 miles west of Montague) JSch, (south of Shasta River) CAS, (Yreka) AMNH; Sonoma County UNHM, (Cloverdale) CUNY, (Del Puerto Creek) TLEr, (Dry Creek, 9.0 miles northwest of Healdsburg) SJSC, (Guerneville) CAS, (2.0 miles east of Healdsburg) CAS, (Rio Nido) CAS, (Santa Rosa) CUNY, MCZ, OUCO; Tehama County (Red Bluff) CAS; Trinity County CMPP, (Mad River) TLEr, (0.7 miles northwest of Ruth Dam) GRNo, (Weaverville) UWSW; Yolo County (Davis) CBak, UCD; Counties unknown (Aliso) UWSW, (Latrobe) CAS, (San Antonio Mission) CUNY, (Sylvania) CAS. OREGON: Douglas County (North Umqua River, near Winchester) JSch, (7.0 miles northwest of Roseburg) JSch, (Winchester) JSch; Jackson County (Eagle Point) CAS, (Medford) CAS, UCD, (8-14.0 miles south of Ruch) JSch, (10.0 miles south of Ruch) JSch, (Talent) UCD, (Trail) JSch, LRus; Josephine County (Applegate River) OSUC,

(Illinois River) JSch, (Selma) JSch; Umatilla County (Umatilla) MCZ. WASHINGTON: Spokane County (Spokane Falls) MCZ; Walla Walla County (Walla Walla) OSUC.

4.61 The *fumans* group

This group is characterized by the virga, the sides of which are curled over ventrally from base to apex, forming a central trough. The diversity of this group warrants its division into twelve subgroups.

4.611 The *cinctipennis* subgroup

The members of this subgroup are characterized by an elytral ferrugineous sutural stripe and a long narrow median lobe. Two species, *B. cinctipennis* Chevrolat and *B. cibolensis* new species, are included.

4.6111 *Brachinus cinctipennis* Chevrolat
(Figs. 203, 206, 207, 208, 221, 225)

Brachinus cinctipennis Chevrolat, 1835:163. Lectotype, here selected, a male, HMO, Type number Col. 113 1/3, further labelled "Brachinus cinctipennis Chev. Col de M. Z cent no 163 Mexico plaine de Mexico Aout sous des pierres Sallé 59."

Type locality.—The highplain of Mexico, as originally given by Chevrolat, but herewith restricted to the State of Mexico, Mexico.

Diagnostic combination.—The ferrugineous sutural stripe on the elytra, together with the pale palpi, and extensively pale legs,

separate these beetles from all others of the genus.

Description.—Medium-sized beetles, 6.6 to 9.4 mm.

Color. Antennal articles 3-11, apex of femur, mesepisterna, metepisterna, metasternum at sides, and abdominal sterna and terga infuscated, otherwise ferrugineous. Dorsal surface of elytra greenish-blue with ferrugineous sutural stripe epipleura testaceous.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and surface of pronotum slightly rugose and punctate, punctures barely impressed.

Head. Frontal furrows moderately impressed. Antennal scape cylindrical. Ligule with sclerotized center area ellipsoid-convex with two lateral rows of three setae per row.

Prothorax. Pronotum (fig. 203) convex, sides barely reflexed. Proepipleura glabrous. Proepisterna with a few scattered setae both anteriorly and posteriorly. Anterior tibia with anterior surface strigose.

Pterothorax. Elytra elongate, narrow, barely costate. Humeral angle square. Costae and depressions pubescent. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 206, 207, 208). Median lobe with plane of shaft rotated 45^{o} from plane of basal bend. Basal bend long. Apex of shaft narrow, rounded. Ligule short, narrow, narrowly rounded apically. Virga (figs. 206, 207). Female (fig. 225). Stylus short, broad, narrowly rounded apically.

Variation.—Intrapopulational variation occurs in the following characteristics: presence or absence of accessory setae on the

submentum; number of setae on the ligula; extent of infuscation on the tibia; width of the sutural stripe; and the color of the elytra.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Latin, cinctus = belt; pennis = wing; referring to the broad, sutural stripe on the elytra of these beetles.

Collecting notes.—G. E. Ball and I collected these beetles from beneath stones at the edge of an artificial pond in Jalisco, Mexico.

Life history.—Members of this species have been collected in April, June to September, November, and December. Teneral adults were collected in April in Puebla, Mexico.

Distribution.—(Fig. 221). The range of this species extends from San Luis Potosi to Puebla. I have seen 105 specimens from the following localities:

MEXICO

AGUASCALIENTES: (Aguascalientes) AMNH; (El Rotono, 10.0 miles east of Auascalientes) AMNH. DISTRITO FEDERAL: CPBo, (Mexico City) AMNH, BMNH, CUNY, TMBH. JALISCO: (Encarnacion de Diaz) UASM; (5.0 miles west of Lagos) UATA; (13.0 miles southeast of Lagos de Moreno) USNM; (12.0 miles west of Ojuelos) CAS. MEXICO: (Lago Zumpango, near San Juan Zitlaltepec) UASM. PUEBLA: (Lago Totolcingo, near Tlaxcala line) UASM. SAN LUIS POTOSI: (San Luis Potosi) AMNH. STATE UNKNOWN: (Presa de Angulo) JHen.

4.6112 Brachinus cibolensis new species

(Figs. 202, 209, 210, 211, 219, 223)

Type locality.—Five miles west of Portal, Southwest Research

Station, 5,400 feet, Cochise County, Arizona.

Type specimens.—The holotype male and allotype female are in the entomological museum at AMNH. The holotype was collected by E. Ordway, and the allotype was collected by M. Statham at the type locality on July 27, 1956 and May 8, 1958, respectively. Five paratypes collected in various localities on various dates are in AMNH, CAS, MCZ, TLEr, and UASM.

Diagnostic combination.—The ferrugineous sutural stripe on the elytra, together with the entirely black legs and palpi, separate these beetles from all others in Mexico and United States.

Description.—Medium-sized beetles, 7.5 to 9.8 mm.

Color. Palpi, antennal articles 2-11, metepisterna, metasternum at sides, legs, and abdominal terga and sterna infuscated to black. Dorsal surface of elytra blue with ferrugineous sutural stripe, epipleura testaceous.

Microsculpture. As described for genus.

Macrosculpture. As in cinctipennis.

Head. As in cinctipennis.

Prothorax. As in cinctipennis. Pronotum (fig. 202).

Pterothorax. As in cinctipennis.

Abdomen. As described for genus.

Genitalia. Male (figs. 209, 210, 211). Median lobe with plane of shaft rotated 45° from plane of basal bend. Basal bend long. Shaft long and narrow, apex rounded, slightly notched. Ligula short, tapering to narrowly rounded apex. Virga (figs. 209, 210). Female (fig. 223). Stylus short, broad, tapering to narrowly rounded apex.

Variation.—Intrapopulational variation occurs in the shape of the pronotum, width of the sutural stripe on the elytra, and in the color of the elytra and antennal articles 2-11.

Flight.—These beetles have been collected at lights at Douglas, Arizona, Lordsburg, New Mexico, and Durango City, Mexico.

Etymology.—Cibola, from the legendary Seven Cities of Cibola that Coronado searched for in the American Southwest; Latin, ensis = denoting place, locality, or country.

Collecting notes.—G. E. Ball collected these beetles from under stones at the margin of a dirt water tank in the Chiricahua Mountains of Arizona.

Life history.—Members of this species have been collected from June to September, but no teneral adults were seen.

Distribution.—(Fig. 219). The range of this species extends from northern Arizona to Durango City, Mexico. I have seen 78 specimens from the following localities:

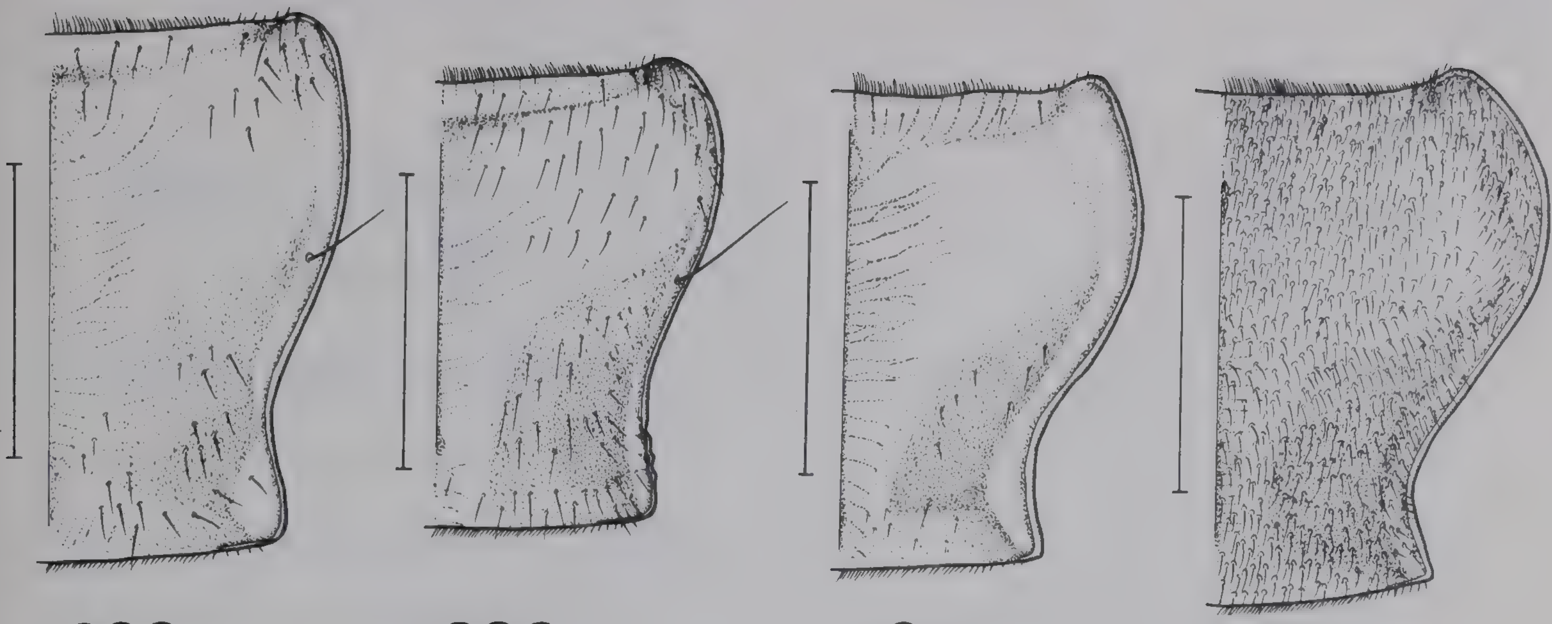
MEXICO

DURANGO: (Durango) AMNH, UASM; (15.0 miles west of Durango) CNC.

UNITED STATES

ARIZONA: Cochise County (Benson) UATA, (Douglas) CUNY, UASM, UCR, (near Paradise) UASM, (Portal) GRNo, (San Bernardino Ranch) ZMLS, (South West Research Station, 5.0 miles west of Portal) AMNH, UCD, (Tombstone) SDNHM, (Willcox) AMNH, UATA; Coconino County (Bill Williams Fork) AMNH; Santa Cruz County (Nogales) CAS, CNHM, UCR. NEW MEXICO: Bernalillo County (Albuquerque) CMPP, USNM; Hidalgo County (Animas) AMNH, (Lordsburg) CNC, UCR, (Rodeo) CUNY, UCD; Socorro County (Socorro) CAS.

Figs. 202-205. Pronotum, right half, dorsal aspect. 202. *Brachinus cibolensis* new species, near Paradise, Arizona. 203. *Brachinus cinctipennis* Chevrolat, 13.0 miles southeast of Lagos de Moreno, Jalisco, Mexico. 204. *Brachinus pallidus* Erwin, Kings Canyon, California. 205. *Brachinus hirsutus* Bates, Sonoyta, Sonora, Mexico. Figs. 206-217. Male genitalia. 206. *Brachinus cinctipennis* Chevrolat, 13.0 miles, southeast of Lagos de Moreno, Jalisco, Mexico, ventral aspect. 207. Lateral aspect of same. 208. Dorsal aspect of same. 209. *Brachinus cibolensis* new species, Douglas, Arizona, ventral aspect. 210. Lateral aspect of same. 211. Dorsal aspect of same. 212. *Brachinus hirsutus* Bates, Sonoyta, Sonora, Mexico, ventral aspect. 213. Lateral aspect of same. 214. Dorsal aspect of same. 215. *Brachinus pallidus* Erwin, Kings Canyon, California, ventral aspect . 216. Lateral aspect of same. 217. Dorsal aspect of same. Accompanying scale lines equal 1.0 mm.



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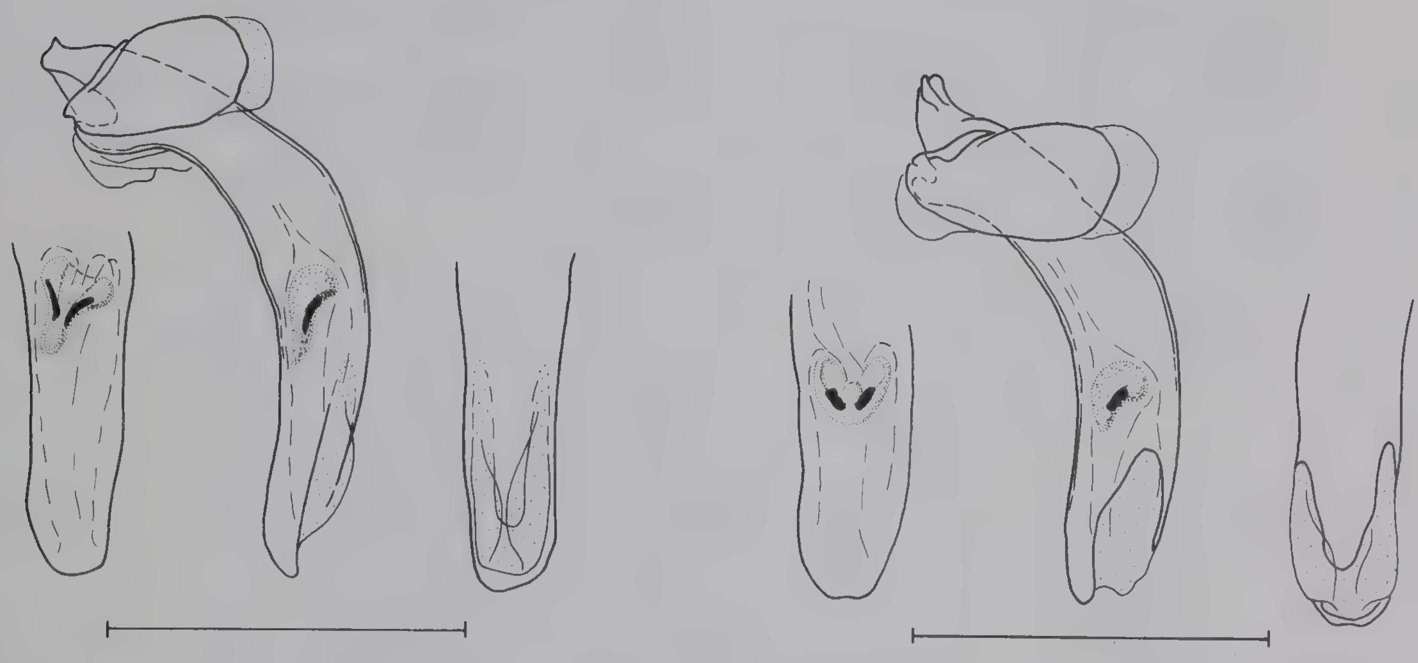

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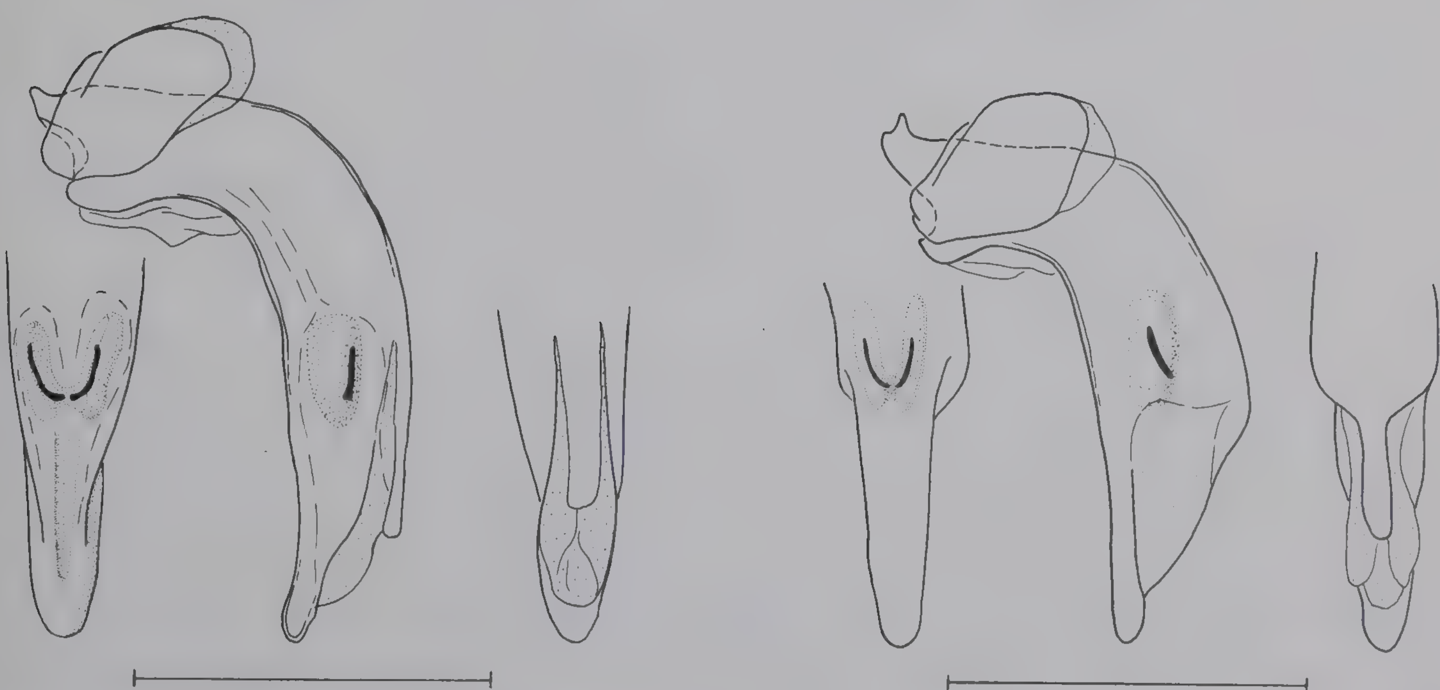
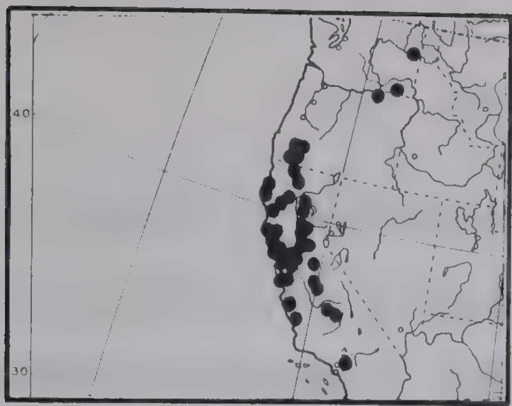


212 213 214 215 216 217

Figs. 218-221. Geographical distribution maps. 218. *Brachinus pallidus* Erwin. 219. *Brachinus cibolensis* new species. 220. *Brachinus hirsutus* Bates. 221. *Brachinus cinctipennis* Chevrolat.

Figs. 222-225. Right stylus of female ovipositor, ventral aspect. 222. *Brachinus pallidus* Erwin, Kings Canyon, California. 223. *Brachinus cibolensis* new species, near Paradise, Arizona. 224. *Brachinus hirsutus* Bates, Rio Chico, Durango, Mexico. 225. *Brachinus cinctipennis* Chevrolat, 13.0 miles southeast of Lagos de Moreno, Jalisco, Mexico. Accompanying scale line equals 1.0 mm.



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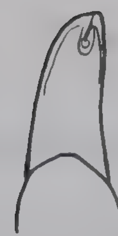

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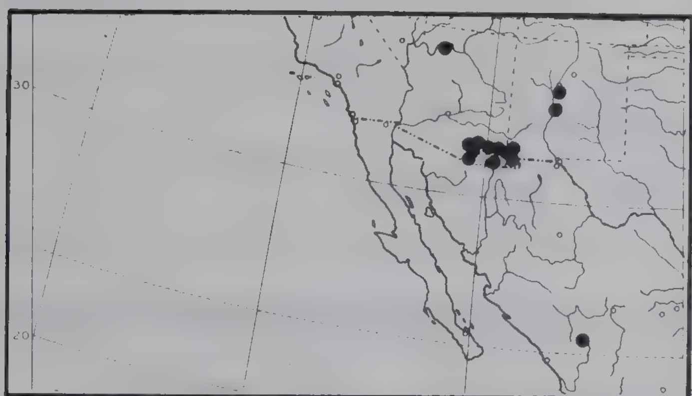

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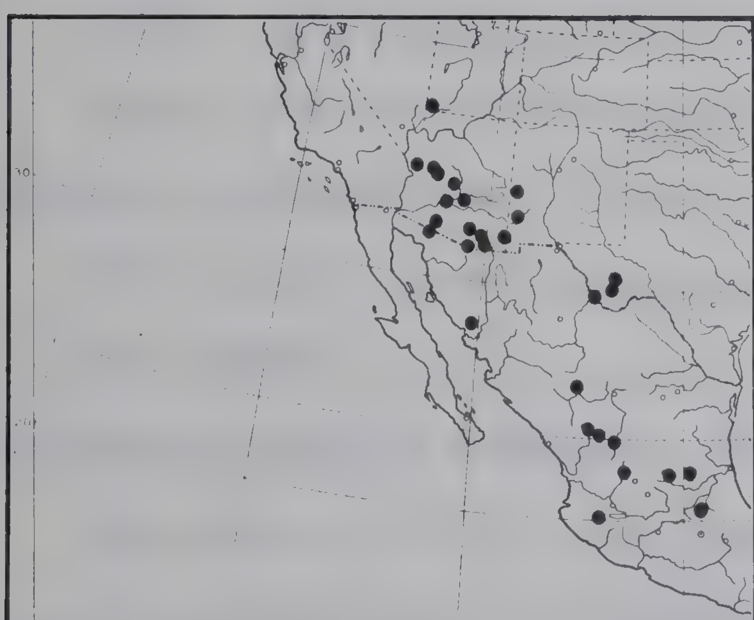

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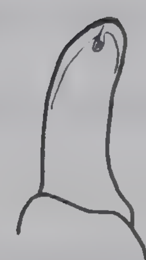

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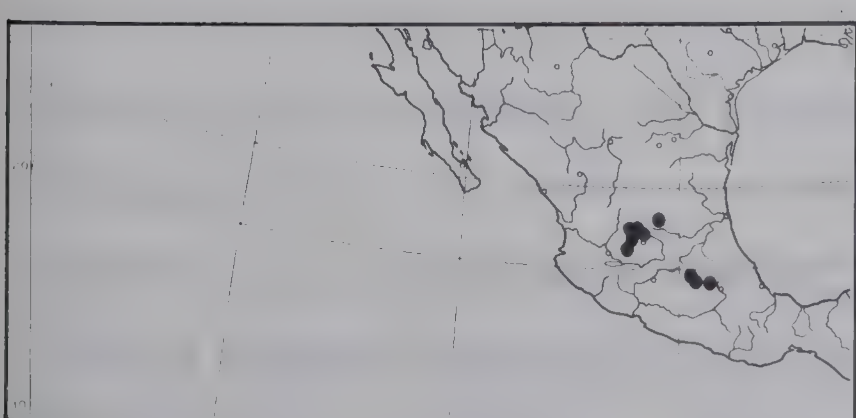

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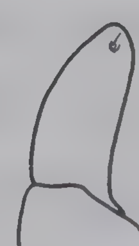

225

4.612 The *quadripennis* subgroup

The members of this subgroup are characterized by the presence of a ridge on the ventral surface of the male genitalia. Five species, *B. quadripennis* Dejean, *B. mexicanus* Dejean, *B. neglectus* LeConte, *B. javalinopsis* new species, and *B. kavanaughi* new species, are included.

4.6121 *Brachinus quadripennis* Dejean
(Figs. 230, 240, 241, 242, 247, 251)

Brachinus quadripennis Dejean, 1825:316. Lectotype, here selected, a female, MHNP, labelled "quadripennis m. in Amer. bor." and "Lherminier" on green paper, and "Ex Museo Chaudoir" on white paper. *Type locality*.—North America, as originally given by Dejean, but herewith restricted to Florida.

Brachinus stygicornis Say, 1834:415. Neotype designated by Lindroth (MS), a male, in MCZ. *Type locality*.—South Bend, Nebraska. NEW SYNONYMY.

Brachinus tschernikhi Mannerheim, 1843:184. Types presumed lost (see Erwin, 1965:13). *Type locality*—California, as originally given by Mannerheim. NEW SYNONYMY.

Notes.—The neotype designated by Lindroth for *B. stygicornis* was selected by me from the Nebraska University material I had on loan, and sent to Lindroth. He subsequently deposited all Say's neotypes in MCZ. The specimen was labelled "South Bend, Neb." "5/8/09" and "R. W. Dawson Collection." This locality is the nearest to Say's original area from which we had specimens. The original area was "crevices of rocks...Engineer Cantonment, near Council

Bluff."

The name _B. sejungenius_ Chaudoir is found on some of Chaudoir's specimens in MHNP. This name was never published, and therefore not really in existence, but I add this note to stop future confusion for which this genus is noted.

Diagnostic combination.—The diagnostic characters are given in the key, but in most cases the infuscated tarsi and tibiae will separate these beetles from all others of the genus in the United States, except individuals of _B. phaeocerus_ and _B. azureipennis_. The members of _phaeocerus_ are smaller and have bright blue elytra, while the members of _azureipennis_ are larger, have black palpi and antennae, and have metallic blue luster on the infuscated abdomen.

Description.—Medium-sized beetles, 7.8 to 11.0 mm.

Color. Palpi, antennal articles 3 and 4, mesepimera, tibiae, and tarsi usually infuscated. Abdominal sterna, terga, metepisterna, and metasternum at sides infuscated to black, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows, and sometimes disc of pronotum rugose, sparsely punctate, punctures barely impressed.

Head. Frontal furrows moderately impressed. Antennal scape cylindrical. Ligula with sclerotized center area ellipsoid-convex with two or three setae apically. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 230) slightly convex, flattened along center line, sides slightly reflexed. Proepipleura glabrous. Proepisterna with a few setae anteriorly and posteriorly, glabrous

while the members of azurelpennis are larger, have black pelpt and

medially. Anterior tibia with anterior margin strigose.

Pterothorax. Elytra elongate, narrow, moderately costate. Humeral angle variable, but usually prominent or at least square. Costae smooth on disc, depressions pubescent. Wings entire.

Abdomen. As described for genus.

Genitalia. Male (figs. 240, 241, 242). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend short. Apex of shaft narrowed, ridged ventrally. Ligule short, broad, narrowed apically. Virga (figs. 240, 241), elongated. Female (fig. 247). Stylus broad, parallel-sided, rounded apically.

Variation.—The color of the tibiae, tarsi, and palpi vary from almost black to ferrugineous. The pale form occurs infrequently in the northwestern populations, but is common in the midwestern, eastern, and Floridian populations. Variation also occurs in the shape of the pronotum and humeral angle within single population samples.

Flight.—These beetles have been collected repeatedly at lights throughout the range of the species, especially Florida.

Etymology.—Latin, quadratus = square, pennis = wing; referring to the square shape of the elytra.

Collecting notes.—L. Russell collected these beetles on the floodplain of the Flathead River near Perma, Montana. They were beneath short grass, matted with algae, near an ephemeral pond formed by river floodwaters.

Life history.—Members of this species have been collected from January to September, and teneral adults have been collected in March in Florida, and in August in Washington and Michigan. These beetles

probably overwinter as adults.

Distribution.—(Fig. 251). There are six areas from which these beetles have been commonly collected. These are the northwestern United States and adjacent Canada; the Great Salt Lake area; the areas drained by the Mississippi, and its northern tributaries east of longitude 105°, including the Great Lakes Region, New England, Florida and the eastern part of the Gulf Coast, and Brownsville, Texas. I have seen 2,405 specimens from the following localities:

CANADA

ALBERTA: (Medicine Hat) UASM. BRITISH COLUMBIA: (Kamloops) MCZ; (Oliver) CNC; (Osoyoos) CAS, UATA. MANITOBA: (Aweme) UONO. ONTARIO: (Saint Williams, southwest of Simcoe) ZMLS. SASKATCHEWAN: (Kenosee) UNSS.

UNITED STATES

ALABAMA: Mobile County (Magazine Point) CAS. ARIZONA: (No locality given) USNM. ARKANSAS: Bradley County (8.0 miles south of Warren) JSch; Mississippi County (Osceola) UMAH; Washington County (No locality given) UAFA. CALIFORNIA: Fresno County (Friant) CAS; Kings County (Hanford) USNM; Lake County (Cache Creek) UCR, (Clear Lake) CAS, (Lower Lake) CAS; Los Angeles County USNM, (Pasadena) CMPP; Merced County (Los Banos) CAS, TLEr; Sacramento County (Sacramento) TLEr, UCD, UIMI; Yolo County (Causeway) UCD, (Clarksburg) UCD, (Davis) CAS, TLEr, UCD, UIMI. SOUTH DAKOTA: Beadle County (Huron) VMKi; Brookings County (Brookings) VMKi, (White) VMKi; Lawrence County (Spearfish) VMKi; Union County (Elk Point) VMKi; Yankton County (Yankton) VMKi. FLORIDA: Alachua County (Gainesville) CNC, FDAG, TLEr, UMAH, USNM, (Newnans Lake, 5.0 miles east of Gainesville)

RFre, UASM; Broward County (Fort Lauderdale) UMAH; Charlotte County (Punta Gorda) CNC, PSUU; Collier County (Everglades) USNM; Columbia County (O'Leno State Park) CUNY; Dade County FDAG, (3.0 miles south of Florida City) AMNH, (Homestead) CNC, TLEr, (Long Pine Key) MCZ, (Miami) CAS, (Royal Palm State Park) PUM; De Soto County (Arcadia) CUNY; Duval County (Jacksonville) ISNM; Glades County (Palmdale) AMNH; Hendry County (Clewiston) OUCO; Highlands County (Archbold Biology Station) AMNH, CEWh, CMPP, CUNY, PSUU, RCGr, (Brighton) UASM, (Fish Eating Creek, 4.0 miles west of Venus) RCGr, (Highlands Hammock State Park) TLEr; Hillsborough County (Tampa) USNM; Lee County (Fort Myers) AMNH, CUNY; Levy County FDAG, (Manatee Springs State Park) RFre, UASM, (Williston) UWSW; Liberty County (Camp Torreya) UMAH; Manatee County (Bradenton) FDAG, (Oneco) CNC, CUNY, UASM; Marion County (No locality given) MCZ; Okeechobee County (Lake Okeechobee, 6.0 miles south of Okeechobee) UASM; Orange County (Winterpark) MCZ; Palm Beach County (Belle Glade) CUNY, (North New River Canal) UASM; Pinellas County (Clearwater) CNHM, (Dunedin) CAS, CUNY, PUM, (Tarpon Springs) CNC, CNHM; Polk County (Lakeland) UMAH, (Lake Wales) FDAG, USNM, (Winter Haven) FDAG; Saint Johns County (Ponte Vedra Beach) AMNH, (Saint Augustine) AMNH; Sarasota County (Myakka River State Park) CUNY, UASM, (Sarasota) PUM; Seminole County (Sanford) CUNY, FDAG, JSch, PUM, USNM; Volusia County (Enterprise) CAS, USNM, (Ormond) AMNH; Counties unknown (Belleair) AMNH, (Fort Capron) ISNM, (Lake Harney) USNM, (Sand Point) USNM. GEORGIA: Lowndes County (No locality given) OUCO; Thomas County (Thomasville) CNHM, USNM. IDAHO: Bonner County (Sagle) UWSW; Latah County (Moscow) CMPP. ILLINOIS: (No locality given) ISNH.

INDIANA: Vigo County (No locality given) PUM, UWMW; Posey County (Hovey Lake) PUM; County unknown (Mineral Springs) CMPP. IOWA: Boone County (Ledges State Park) ISUA; Dickinson County (Lake Okoboji) USNM, (Milford) USNM; Emmet County (No locality given) CAS; Henry County (Mount Pleasant) RTBe; Johnson County (Iowa City) MCZ, USNM; Palo Alto County (Ruthven) ISUA, (Silver Lake) USNM; Sioux County (Howarden) VMKi; Story County (Ames) ISUA, MSUM, OSUC, USNM, (Soper's Mill Dam, 3.0 miles east of Gilbert) ISUA; Woodbury County (Sioux City) UMSP. KANSAS: Atchison County (Atchison) CMPP; Douglas County CUNY, (Lawrence) UWMW; Pottawatomie County (Onaga) CAS; Riley County (Manhattan) KSU; Rooks County (No locality given) KSU; Saline County (Salina) CAS, CMPP, MCZ, PUM, ZMLS; Sheridan County (State Lake, near Studley) RFre. LOUISIANA: Orleans Parish (New Orleans) ANSP. MASSACHUSETTS: Hampden County (Longmeadow) USNM; Hampshire County (Mount Tom) MCZ; Middlesex County (Arlington) MCZ, (Concord) MCZ, (Newton) MCZ, (Waltham) MCZ; Suffolk County (Dorchester) MCZ; County unknown (Forest Hills) MCZ. MICHIGAN: Huron County (Point aux Barques) UMAH; Ingham County (East Lansing) UATA; Macomb County (Mount Clemens) CNHM; Marquette County (Marquette) CAS; Oakland County (Milford) UMAH; County unknown (Aurelius) JSch. MINNESOTA: Big Stone County UMSP, (Ortonville) ISNH; Clearwater County (Lake Itasca) UMSP; Houston County (Mississippi Bluff, 1-2.0 miles north of State Line) UMSP; Jackson County (Jackson) USNM; Lincoln County (Lake Benton) VMKi; Lyon County (No locality given) UMSP; Norman County (No locality given) UMSP; Olmsted County (No locality given) UMSP; Polk County (Crookston) UMSP; Ramsey County (Saint Paul) UMSP; Saint Louis County (Duluth) ISNH; Stearns County

(Koronis Lake, Paynesville) USNM; Washington County (No locality given) UMSP; Wright County (No locality given) UMSP. MISSOURI: Atchison County (Langdon) AMNH; Callaway County (Readsville) MCZ; Jackson County (Kansas City) KSU; Saint Louis County (Ranken) JSch; Wayne County (Williamsville) CNC; Wright County (Gull Creek, west of Mount Grove) TCBa: MONTANA: Cascade County (Great Falls) CAS; Flathead County (Kalispell) USNM; Sanders County (Perma) LRus. NEBRASKA: Cass County (South Bend) UNLN; Cuming County (West Point) UNLN; Dakota County (South Sioux) UNLN; Dodge County (Fremont) UNLN; Douglas County (Childs' Point, Omaha) CAS, UNLN; Lancaster County (Lincoln) UNLN, (Malcolm) USNM, (Roca) UNLN; Otoe County (Nebraska City) UNLN; Sarpy County (Bellevue) UNLN; Saunders County (Ashland) SDSU, UNLN, (Cedar Bluffs) UNLN, USNM; Thomas County (Halsey) UMAH; York County (Bradshaw) UNLN, (York) UNLN. NEVADA: ANSP, USNM, MCZ, ISNH, Humboldt County (Golconda) CBak; Washoe County (Reno) RTBe. NEW JERSEY: Cape May County (Five Mile Beach) OUCO; Gloucester County (Woodbury) USNM. NEW YORK: Suffolk County (Montauk) CNHM. NORTH DAKOTA: Benson County (11.9 miles west of York) UASM; McKenzie County (North Roosevelt National Park) AMNH; Morton County (Heart River, 5.0 miles west of Mandan) UASM; Ramsey County (Devils Lake) MCZ, USNM, ZMLS. OHIO: Ashtabula County (Jefferson) USNM; Wood County (No locality given) PUM. OREGON: Baker County UMAH, (Wallowa Mountains) CAS; Curry County (8.0 miles east of Gold Beach) OSUC; Lake County (Hart Lake) JSch; Wasco County (The Dalles) MCZ, USNM; Umatilla County (Umatilla) MCZ; Union County (Alicel) RESt, UIMI; County unknown (Stein Mountains) CAS. PENNSYLVANIA: Allegheny County (Pittsburgh) CMPP. SOUTH DAKOTA: Bon Homme County

(Springfield) VMKi; Brookings County (Brookings) CMPP, SDSU, VMKi, (Volga) CAS, MCZ, USNM, VMKi, (White) VMKi; Brown County (Stratford) LACM; Brule County (Chamberlain) SDSU; Buffalo County (Fort Thompson) SDSU; Clay County (Vermillion) SDSU; Haakon County (Philip) SDSU; Hughes County (Pierre) VMKi; Jones County (Murdo) SDSU; Kingsburg County (Erwin) USNM; Turner County (Centerville) VMKi; Union County (Elk Point) SDSU, VMKi; Yankton County (Yankton) VMKi; County unknown (Darwood Lake) VMKi. TENNESSEE: Lake County (Gray's Lodge) RTBe. TEXAS: Cameron County (Brownsville) CNC, CNHM, CUNY, OUCO, USNM. UTAH: Cache County (Logan) USUL, (Smithfield) USUL, (Wellsville) USUL; Salt Lake County (Salt Lake City) UIMI, USNM, UWSW; Utah County (Provo) MCZ, UASM, USNM, (Provo Canyon, 1.0 miles south of Springdale) UMSP, (Utah Lake, Provo) UASM, UMAH. WASHINGTON: Adams County (Lake McElroy) CAS, USNM, UWSW, (Othello) UWSW, (Ritzville) CAS, CMPP, MCZ, PUM, UMAH, USNM; Franklin County (Kahlotus) UWSW; Grant County (Coulee City) CAS, UWSW, (Crab Creek) UWSW, (Grand Coulee, Dry Falls) WSUP, UWSW, ZMLS, (Grand Coulee, Meadow Creek) WSUP, (Moses Lake) JSch, UWSW, (Smyrna) UWSW, (Soap Lake) UWSW, (Steamboat Rock) UWSW, (Stratford) CAS; Kittitas County (Vantage) UWSW; Lincoln County (Sprague) CAS, CMPP, PUM, UWSW, (Sprague Lake) CAS, (Wilbur) UASM; Okanagon County (5.0 miles south of Tonasket) CNHM; Spokane County (Cheney) JSch, UWSW, (Medical Lake) UWSW; Yakima County (Toppenish) UWSW. WISCONSIN: Dane County (No locality given) UWMW.

4.6122 _Brachinus_ _mexicanus_ Dejean

(Fig. 234, 235, 236, 244, 248, 252)

Brachinus _mexicanus_ Dejean, 1831:428. Lectotype, here selected, a male, MHNP, labelled "mexicanus m. in Mexico" "Hopfner" on green paper, and "Ex Museo Chaudoir" on white paper. _Type_ _locality_.—Mexico, as originally given by Dejean, but herewith restricted to Baja California, Mexico.

Brachinus _fidelis_ LeConte, 1862:524. Lectotype, here selected, a female, MCZ red type label number 5852. Further labelled with a gold disc and "B. fidelis Kern. LeC." _Type_ _locality_.—Kern County, California, here designated, based on LeConte's labels. NEW SYNONYMY.

Brachinus _convexus_ Chaudoir, 1837:7. Lectotype, here selected, a female, MHNP, labelled "convexus Mex. Chaud." and "Ex Museo Chaudoir." This specimen is pinned beneath a specimen of _B_. _mexicanus_ Dejean, and placed in that series. _Type_ _locality_.—Mexico, as given on Chaudoir's label. NEW SYNONYMY.

Brachinus _lecontei_ Motschulsky, 1859:139. Primary homonym of _B_. _lecontei_ LeConte, 1844:49. (see Erwin, 1965:10).

Diagnostic _combination_.—The diagnostic characters are given in the key, but these beetles can be separated from all others in the study area by elytral pubescence restricted to depressions 6, 7, and 8, dark venter, blue elytra, and lack of accessory setae on the mentum.

Description.—Medium-sized beetles, 7.5 to 9.6 mm.

Color. See under Variation, below.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and disc of pronotum rugose, sparsely punctate, punctures weakly impressed.

Head. Frontal furrows moderately impressed. Antennal scape robust, widest at middle. Ligula with sclerotized center area ellipsoid-convex with two lateral rows of three setae each. Mentum and submentum without accessory setae.

Prothorax. As in quadripennis, except proepipleura variable. Pronotum (fig. 244).

Pterothorax. Elytra as in quadripennis, except costae variable and pubecence confined to depressions 6, 7, and 8, scutellar region, and across the apical sixth of the elytra. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 234, 235, 236). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend short. Apex of shaft various, ridged ventrally. Ligule short, broad, narrowed apically. Virga (figs. 234, 235). Female (fig. 248). Stylus broad, tapering to acute apex.

Variation.—The composition of this species seems to be more complex than most Brachinus species in the study area. Two forms are clearly recognizable in most of the range, except California. I refer to these forms as the "high-costae morph" and the "low-costae morph." In California, these two forms merge in all characteristics, with local populations having both the extreme and intermediate forms. In Mexico, the high-costae morph is known only in northern Baja California (Cataviña). Other populations are in Phoenix, Arizona, southern New Mexico, Hope, Arkansas, Chicago,

Illinois, and Brookings, South Dakota. In Phoenix, there appears to be a mixed population, but the specimens seen were collected at different times. Except for the last three mentioned peripheral localities, the range of the low-costae morph overlaps that of the high-costae morph.

The high-costae morph generally has pale antennae, pale abdominal center, well developed costae, and a few setae on the proepipleura. The low-costae morph is quite dark beneath, the abdominal center is infuscated, the third and fourth antennal articles are at least clouded, the outer articles are infuscated rather than being dusky, and finally the proepipleuron is usually glabrous.

Further variation occurs in the male genitalia. In the low-costae morph the shaft is narrowed to apex, and the virga tapers evenly to the apex. The high-costae morph has the apex of the shaft almost truncate, and the virga is pinched medially.

The flattened rim of the female stylus is more pronounced in the low-costae morph than in the high-costae morph, but the general shape is the same.

<u>Flight</u>.—These beetles have been collected repeatedly at lights throughout the range of the species.

<u>Etymology</u>.—The latinized form of Mexico, where the types were collected.

<u>Collecting notes</u>.—I have collected these beetles on numerous occasions in California, New Mexico, and Mexico. They are always near water, either standing or flowing. At Rancho Nuevo, Chiapas they were beneath logs in grassy soil. In Santa Clara County, California they occur under stones in gravel covered with algae

and finally the proepipleuron is usually glabrous.

near stream margins.

Life history.—Members of this species have been collected in all months of the year. The life cycle is much the same as in B. pallidus (Erwin, 1967).

Distribution.—(Fig. 252). The range of this species extends from Washington south to at least Guatemala, and east to Arkansas and Illinois. I have seen 2,603 specimens from the following localities:

CENTRAL AMERICA

GUATEMALA: (No locality given) MCZ.

MEXICO

AGUASCALIENTES: (Aguascalientes) CNHM; (11.0 miles west of Aguascalientes) UASM; (15.0 miles west of Pabellon) UMAH. BAJA CALIFORNIA: (Arroyo de Purisima) CAS; (Arroyo del Rosario) CAS; (Cataviña) CAS; (south of El Sauzal) CAS; (1.3 miles northwest of El Triunfo) CAS; (Hamilton Ranch) CAS; (La Mision) GRNo; (12.4 miles east of La Paz) CAS; (Mira Flores) CAS; (Rancho Stacion Salsipuedes) UMSP; (San Ignacio) CAS; (3.0 miles east of San Isidro) CMPP; (San Vicente) CAS; (Tijuana) CNHM; (65.0 kilometers south of Tijuana) LACM; (Triunfo) CAS. CHIAPAS: (15.6 miles west of Comitan) UASM; (Rancho Nuevo, 8.6 miles east of San Cristobal) RTBe, UASM; (1.0 miles north of San Cristobal) RTBe; (8.6 miles east of San Cristobal) UASM. CHIHUAHUA: (Carta Blanca, 16.0 miles west of Matachic) AMNH; (Catarinas) AMNH; (Chihuahua City) AMNH; (25.0 miles northwest of Chihuahua City) CNC; (Primavera) AMNH; (San Jose Babicora) AMNH. COAHUILA: (Arroyo Palo Blanco, 15.0 miles north of Saltillo) DRWh; (Saltillo) AMNH, MCZ. DISTRITO

FEDERAL: (Peñon Viejo) MCZ. DURANGO: (12.2 miles south of El Banco) UASM; (Encino) AMNH; (Nombre de Dios) AMNH; (Rio Chico, 15.7 miles west of Durango) UASM. GUANAJUATO: (Rio Guanajuato, 9.8 miles south of Sialo) UASM. GUERRERO: (13.9 miles west of Chilpancingo) UASM. HIDALGO: (Guadalupe) MCZ; (Huichapan) LACM; (Rio Tula, near Tasquillo) UASM; (Tula) JHen. JALISCO: (Ajijic) JHen, UATA; (4.0 miles west of Ajijic) AMNH; (21.4 miles south of Encarnacion de Diaz) UASM; (Cocula) USNM; (9.1 miles northwest of Cautla) UASM; (Guadalajara) AMNH, MCZ; (9.0 miles east of Guadalajara) AMNH; (13.0 miles southeast of Lagos de Moreno) UASM; (17.9 miles west of Magdalena) UASM; (12.0 miles west of Ojuelos de Jalisco) CAS; (Puente Caquixtle, 9.7 miles east of Encarnacion de Diaz) UASM; (Rio Grande de Santiago, 12.5 miles west of Ixtlahuacan del Rio) UASM; (21.0 miles northeast of Tepatitlan) CAS; (Valle de Guadaloupe) CAS. MEXICO: (Lago Zumpango, near San Juan Zitlaltepec) UASM; (Tempascaltepec) CAS; (7.0 miles north of Tenancingo) UASM; (Tonatico) JHen; (Valle de Bravo) JHen; (Villa Carbon) JHen. MICHOACAN: (7.0 miles south Ario de Rosales) UASM; (10.0 miles west of Jiquilpan) DRWh; (Morelia) UASM; (Tuxpan) JHen; (50.0 miles west of Zitacuaro) MCZ. MORELOS: (Cuernavaca) ANSP; (Progreso) WSUP. NAYARIT: (5.1 miles north of Chapalilla) UASM; (Tepic) UATA; (19.0 miles southeast of Tepic) CAS; (19.3 miles southeast of Tepic) UASM. NUEVO LEON: (3.2 miles south of Galeana) UASM; (1.1 miles east of Iturbide) UASM; (1.3 miles east of Iturbide) UASM; (14.8 miles west of Linares) UASM; (Monterrey) AMNH; (6.0 miles south of Monterrey) FDAG; (Rio Linares, 20.0 miles west of Linares) CAS; (Rio Sabinas Hidalgo, 4.8 miles east of Sabinas Hidalgo) UASM;

(Santa Rosa Cañon, 14.8 miles west of Liñares) UASM. OAXACA: (Mitla) CPBo; (25.0 miles south of Mitla) ISUA; (Oaxaca) AMNH, CAS, MCZ; (Rio Atoyac, near Juchatengo) UASM; (1.4 miles west of Tamazulapan) UASM; (4.3 miles west of Tamazulapan) UASM; (72.5 miles south of Valle Nacional) UASM. PUEBLA: (9.0 miles north of Amatitlan) CAS; (near Petlalcingo) UASM; (Tehuacan) CAS; (near Tehuitzingo) UASM; (1.3 miles south of Tlatlauqui) UASM. QUERETARO: (33.0 kilometers north of Acambay) UASM; (near Palmillas) UASM. SAN LUIS POTOSI: (Puente de la Parada, 7.5 miles northwest of Mexquitic) UASM; (2.0 miles south of San Luis Potosi) CAS; (2.7 miles west of Santa Catarina) UASM. SINALOA: (Culiacan) AMNH; (Real de Piaxtla) AMNH. SONORA: BMNH; (7.2 miles southeast of Alamos) GRNo; (10.0 miles west of Alamos) AMNH; (Cocospera Cañon, 8.0 miles east of Imeris) AMNH; (16.0 miles northeast of Ciudad Obregon) CNC; (Pesqueria) CAS; (Rancho Atascosa, 42.0 kilometers south of Nogales) CNHM; (Rio Mayo, San Bernardo) CAS; (Sonoyta) AMNH. VERACRUZ: (Jalapa) ANSP; (Orizaba) ISUA, UNLN. ZACATECAS: (Rio Juchipila, 0.9 miles north of Jalpa) UASM; (1.3 miles southeast of Sain Alto) UASM. STATE UNKNOWN: (Tujupilco) CAS.

UNITED STATES

ARIZONA: Apache County (White Mountains) CAS, UATA; Cochise County (Benson) CAS, (Bisbee) CAS, (Cave Creek Canyon) PSUU, TCBa, (Cave Creek Ranch) UASM, (Chiricahua Mountains) CAS, OUCO, UASM, UATA, USNM, (Chiricahua Mountains, Rucker Canyon) CAS, (Chiricahua Mountains, Rucker Lake) UASM, (Chiricahua Mountains, Rustler's Park) CNC, (Douglas) CMPP, (Guadalupe Canyon, 32.0 miles east of Douglas) CUNY, (15.0 miles southeast of Hookers Hot Springs) DRWh, (Huachuca

Mountains) OUCO, USNM, (Portal) AMNH, CAS, SJSC, (San Bernardino Ranch) KSU, LACM, (San Pedro River, near Palo minas) UASM, (San Pedro River, 10.0 miles east of Sierra Vista) OSUC, UATA, (South West Research Station, 5.0 miles west of Portal) AMNH, FDAG, GRNo, UCD, UCR, (Tombstone) SDNHM, (Willcox) AMNH; Coconino County (Grand Canyon National Park) CAS, (Havasupai Indian Reservation, Supai Grand Canyon) UMSP; Gila County (Coolidge Dam) SJSC, (Globe) UASM, UATA, (14.0 miles south of Globe) UASM, (Payson) UATA, (Winkelman) UATA; Graham County (Aravaipa) CAS, (Aravaipa Creek, between Klondyke and Aravaipa) DRWh, (Galiuro Mountains) UASM, (Gila River, near Geronimo) UASM, (San Carlos Reservoir) SJSC, UATA; Maricopa County (Phoenix) MCZ, OUCO, UASM, USNM, (Salt River, Phoenix) MCZ, UATA; Mohave County (Beaver Dam) ISUA, (Hubbard Ranch) USNM, (Littlefield) UCD, (16.0 miles north of Wikieup) LACM; Navajo County (Show Low) LACM; Pima County (Baboquivari Mountains, Browns Canyon) AMNH, CAS, (Cienega Creek, Pantano) CUNY, (Coyote Mountains, 0.5 miles north of Mendoza Canyon) UATA, (Saint Xavier Mountains) CAS, (Santa Catalina Mountains) CAS, UATA, USNM, (Santa Catalina Mountains, Bear Canyon) CAS, (Santa Catalina Mountains, Sabino Canyon) CAS, TLEr, UASM, UATA, (Santa Rita Mountains) CAS, (Tucson) CAS, CUNY, UASM, UATA, UIMI, UMAH, USNM; Pinal County (Aravaipa Canyon) CUNY, (Sycamore Camp, 9.0 miles northwest of Payson) CAS; Santa Cruz County (Canelo) UATA, CUNY, (Lewis Springs, San Pedro River) UASM, (Nogales) CAS, CNHM, UASM, UCD, USNM, (Pajarita Mountains) CAS, (Patagonia) CAS, CNHM, CUNY, UATA, (5.0 miles southwest of Patagonia) AMNH, (Peña Blanca) CUNY, OSUC, UASM, (Santa Rita Mountains, Madera Canyon) UASM, UCD, WHTy, (Tumacacori Mountains, Sycamore Canyon) CUNY, (Yanks Spring,

4.0 miles southeast of Ruby) AMNH; Yavapai County (Bumble Bee) CAS, (Camp Verde) PSUU, (Congress) UATA, (Cottonwood) UIMI, (Granite Mountain) CAS, (Prescott) CAS, UASM, USNM, (Wickenburg) ISUA, (5.0 miles north of Wickenburg) UMAH; Counties unknown (Atasco Mountains, Sycamore Canyon) UATA, (Cayetano Mountains) UMAH, (Kohl's Ranch) UATA, (Santa Cruz River) UATA, (Senator) AMNH, (Superstition Mountains) UATA, (Texas Pass) CUNY, (Tortoliita Mountains) CAS. ARKANSAS: Garland County (Hot Springs) CAS, Hempstead County (Hope) MCZ. CALIFORNIA: Alameda County (Livermore) CAS, (Niles Canyon) UCD, (Oakland Hills) CAS, (San Leandro) UIMI; Amador County (5.0 miles west of Sutter Creek) TLEr; Colusa County (Highway 20 and 16) UCD, (Rumsey Canyon) UCD; El Dorado County (No locality given) CAS; Fresno County (La Fevre Creek) CAS; Glenn County (Elk Greek) CAS; Imperial County (Calpatria) CAS; Inyo County (Big Pine) CAS, (Deep Springs Lake) CAS, (Diaz Lake) CAS, (Freeman) CAS, (Independence) CAS, (Little Lake) CAS, (Lone Pine) CAS, (Olancha) CAS, (Owens Lake) CAS, (Owens Lake) CAS, (Westgard Pass Plateau) CAS; Kern County (Caliente) ZMLS; Los Angeles County (Alhambra) CAS, (Arroyo Seco Canyon) VVBa, (Big Dalton Dam) UCR, (Frenchman Flats) CAS, (Los Angeles) CAS, (Pasadena) CAS, (San Dimas) CAS, (Tapica County Park) GRNo; Madera County (Coarsegold) CAS, (O'Neals) UCD; Mariposa County (Mariposa) CAS; Merced County (Merced) CAS; Monterey County (Carmel) UASM, (Jolon) CAS, (3.0 miles southeast of Jolon) CAS, (Stone Canyon) CAS; Napa County (Monticello) UCD; Orange County (Black Star Canyon) UCD, (Laguna Beach) CAS; Placer County (No locality given) CAS; Riverside County (Colton) CAS, (Hemet) VVBa, (Palm Canyon) CAS, (Palm Springs) CAS, (Riverside) CAS, (San Jacinto

Mountains) CAS, (Temecula) CAS; San Benito County (Panoche Valley) CAS; San Bernardino County (Afton Canyon) USNM, (Cajon Pass) UCD, (0.9 miles northeast of Cedar Springs) GRNo; San Diego County (Carrizo) UIMI, (Chicken Creek) CAS, (3.0 miles south of Dehesa) TLEr, (Guatay) UIMI, (Jacumba) CAS, (Knaus) CAS, (Mission Valley) UCD, (Mount Palomar) CAS, (9.0 miles east of Pine Valley) UCD, (Poway) CAS, (San Juan Capistrano) UIMI, (Sweetwater River) RESt; San Joaquin County (Corral Hollow) TLEr; San Luis Obispo County (Atascadero) CAS, (Cambria) CAS, (San Luis Obispo) CAS, (Santa Margarita) CAS; Santa Barbara County (Bluff Camp, San Rafael Mountains) UCD, (Canda del Venedeto) UCD, (Cuyama River) CAS, (Gaviota) CAS, (Santa Cruz Island) CAS, (Santa Ynez River, San Lucas) CAS; Santa Clara County (Alum Rock Park) CAS, (Arroyo Bayo) SJSC, (Gilroy Hot Springs) TLEr, (Pacheco Pass) UIMI, (Uvas Creek) TLEr; Santa Cruz County (Santa Cruz) CAS; Stanislaus County (Del Puerto Canyon) UIMI, (Del Puerto Creek) TLEr; Tehama County (Hills west of Tehama County) CAS; Tulare County (Kaweah) CAS; Ventura County (Fillmore) CAS, (Foster Park) UCD, (Ojai) ZMLS, (Santa Paula) CAS, UCD, (Ventura) CAS, (Wheeler Hot Springs) CAS; Yolo County (Davis) UCD, (Putah Canyon) UCD, (Putah Creek) TLEr. ILLINOIS: Cook County (Riverside) UMAH. NEW MEXICO: Catron County (near Argon) AMNH, (Cooney Canyon, 10.0 miles east of Alama) UASM, (2.0 miles west of Luna) CCha, (San Francisco Creek, 26.1 miles north of Glenwood) UASM; Dona Ana County (Mesquite) LACM; Grant County (Gila River, near Gila) UASM, (Sapillo Creek, 26.0 miles north of Silver City) TLEr, (Silver City) USNM, (16.0 miles west of Silver City) CAS; Hidalgo County (Peloncillo Mountains) GRNo, (Post Office Canyon, 12.0 miles southeast of Rodeo) SJSC, (Rodeo) UCR;

Quay County (Tucumcari) MCZ; San Miguel County (Sapello Canyon) USNM. NEVADA: Humboldt County (Soldier Meadows) NSDA; Kye County (Beatty) OSUC, UWSW; Washoe County (Reno) RTBe, UCD, USNM. OREGON: (No locality given) UMSP. SOUTH DAKOTA: Brookings County (Brookings) ANSP. TEXAS: Blanco County (2.0 miles south of Round Mountain) UASM; Brewster County (Alpine) CAS, CUNY, MCZ, (Big Bend National Park) CNC, MCZ, UASM, (Glenn Springs) UMAH, (Green Valley) CAS, (Saint Helena Canyon) CAS; Cameron County (Brownsville) CMPP, DHKa; Culberson County (2.5 miles east of Nickel Creek Station) CNHM; Fayette County (Flatonia) ANSP; Hudspeth County (9.0 miles west of Sierra Blanca) OUCO; Jeff Davis County (Barrel Springs Creek, 22.0 miles west of Fort Davis) DRWh, (Davis Mountains) CAS, OUCO, UCD, USNM, (Fort Davis) AMNH, CNC, MCZ, (6-10.0 miles west of Fort Davis) UASM, (Limpia Canyon, 2.0 miles northwest of Fort Davis) CNC, CNHM, DRWh, TLEr, UASM; Presidio County (Presidio) TAMU; Reeves County (Balmorhea Lake) UASM, (Pecos) JSch; San Saba County (Camp San Saba) MCZ; Taylor County (25.0 miles southwest of Abilene) CMPP; Travis County (Austin) CAS; Val Verde County (9.0 miles southeast of Del Rio) DRWh. UTAH: Cache County (Logan) USUL; Utah County (Wasatch Mountains, Provo Canyon) CAS; Washington County (3.0 miles south of Gunlock) GRNo, (12.0 miles north of La Verkin) UMSP, (Santa Clara Creek) CAS, UCD, UWSW, (Saint George) AMNH, ISUA, MCZ, USNM, (Zion National Park) CAS. WASHINGTON: Spokane County (Spokane) CAS.

4.6123 Brachinus kavanaughi new species

(Figs. 226, 231, 232, 233, 249, 253)

Type locality.—Superior, Boulder County, Colorado, along Coal Creek.

Type specimens.—The holotype male and allotype female are in CAS. Both were collected by D. H. Kavanaugh at the type locality, on June 4, 1968. Five paratypes collected on various dates and at various localities are in CAS, DHKa, MCZ, TLEr, and UASM.

Diagnostic Combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 8.0 to 12.0 mm.

Color. Antennal article 3 at apex and all of 4, metepisterna, metasternum at sides, abdominal sterna and terga infuscated to black, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and disc of pronotum rugose and punctate, punctures moderately impressed.

Head. As in quadripennis, except antennal scape robust, widest at middle.

Prothorax. As in quadripennis, except proepipleura with setae both anteriorly and posteriorly, glabrous medially. Pronotum (fig. 226).

Pterothorax. As in quadripennis.

Abdomen. As described for genus.

Genitalia. Male (figs. 231, 232, 233). Median lobe with plane of shaft as in quadripennis. Basal bend longer, more arcuate. Apex not so flattened. Ligule short, narrowing apically. Virga

(figs. 231, 232). Female (fig. 249). Stylus broad, but narrowing toward apex.

Variation.—This is a fairly constant species throughout its range. The total size and the shape of the pronotum vary within populations.

Flight.—These beetles have been collected at lights in Del Rio, Texas.

Etymology.—The latinized form of Kavanaugh, named for D. H. Kavanaugh, an excellent collector of carabid beetles who collected the types.

Collecting notes.—Kavanaugh, my wife, and I collected these beetles near the type locality at an elevation of 5,400 feet. They were found beneath stones during the day along a clear cold stream whose edge was composed of stones embedded in clay and gravel, alternating with gravel bars. Beetles of this species also have been collected on the shores of lakes in Colorado by C. Armin.

Life history.—Members of this species have been collected from February to September. Teneral adults were collected in May in Texas and in September in Illinois. Overwintering probably takes place as an adult.

Distribution.—(Fig. 253). The range of this species extends from western New York through the Great Lakes Region, south to Nuevo Leon, Mexico, and west to central Colorado and New Mexico. I have seen 508 specimens from the following localities:

MEXICO

NUEVO LEON: (Monterrey) AMNH; (Rio Blanquillo, 7.0 miles north of Montemorelos) UASM; (Rio Salinas at Cienaga de Flores) UASM.

TAMAULIPAS: (20.0 miles north of Ciudad Victoria) MCZ.

UNITED STATES

COLORADO: Boulder County (Coal Creek, 6.9 miles north of Golden) DHKa, (Coal Creek, Marshall Lake Area) CArm, (Coal Creek, Superior) CArm, DHKa, (Four Mile Creek) CArm, (Hayden) CArm, (Left Hand Creek) CArm, (McCall Lake, Lyons) CArm, (North Saint Vrain, Lyons) CArm, (Red Gulch, Lyons) CArm, (Teller Lake) CArm; Yuma County (Wray) KSU; County unknown (Regnier) AMNH. KANSAS: Comanche County (No locality given) KSU; Montgomery County (Independence) CAS; Riley County (Manhattan) KSU; Sheridan County (State Lake, near Studley) RFre, UASM. ILLINOIS: Cook County (Chicago) CMPP; Knox County (Galesburg) MCZ; La Salle County (Ottawa) RTBe; Vermilion County (Kickapoo) RTBe, (Oakwood) ISNH; County unknown (30.0 miles south of Grape Creek) RTBe, (Horseshoe Lake) RTBe. MISSOURI: Gasconade County (Gasconade River) UWSW; Jefferson County (Kimmswick) UMAH; Saint Louis County (Saint Louis) CAS, SDNHM; Wright County (Gull Creek, west of Mount Grove) TCBa. NEW MEXICO: Bernalillo County (Cedro Canyon) AMNH; Eddy County (Blue Spring, 10.0 miles east of Carlsbad) USNM; San Miguel County (Sapello Creek, Sapello) UASM. NEW YORK: Tompkins County (Ithaca) UASM. NEBRASKA: Banner County (Glen Rock Canyon) UNLN; Glen Sioux County (No locality given) AMNH. OHIO: Franklin County (Columbus) OUCO; Hamilton County (Cincinnati) UMAH; Ottawa County (Put-in-Bay, South Bass Island) UMAH. OKLAHOMA: Comanche County (Wichita National Forest) CAS, OSUS. SOUTH DAKOTA: Lawrence County (Spearfish) VMKi. TEXAS: Blanco County UMAH, USNM, (Round Mountain) OUCO, USNM, (2.0 miles south of Round Mountain) UASM; Brazos County (College Station) TAMU; Burnet County (Inks

Lake State Park) UMSP; Cameron County (Brownsville) CNC, USNM; Comal County (New Braunfels) USNM; Corwell County (No locality given) MCZ; Culberson County (2.5 miles east of Nickel Creek Station) CNHM; Eastland County (No locality given) UMSP; Gillespie County (No locality given) OUCO; Gray County (McClellan) UMSP; Hays County (San Marcos) CAS; Kimble County (Roosevelt) CAS; Lampasas County (Lampasas River) CUNY; Lee County (Fedor) CMPP; McLennan County (Waco) MCZ, USNM, ZMLS; Pecos County (Sheffield) CAS; San Saba County (Camp San Saba) MCZ; Shelby County (Kerrville) CNC; Taylor County (25.0 miles southwest of Abilene) AMNH, CMPP, CNHM; Travis County UMAH, (Austin) AMNH, MCZ, WSUP; Val Verde County (Del Rio) CAS, CNC, (9.0 miles southeast of Del Rio) DRWh; Victoria County (Victoria) USNM; Counties unknown (Fuller) USNM, (Tiger Mills) USNM. WYOMING: Platte County (Glendo Reservoir, near Glendo) DRWh.

4.6124 Brachinus *javalinopsis* new species

(Figs. 227, 228, 229, 245, 246, 254)

Type locality.—Willcox, Cochise County, Arizona.

Type specimens.—The holotype male and allotype female are in AMNH. Both were collected at the type locality by T. Cohn, P. Boone, and M. Cazier on September 7, 1950. Three paratypes collected on the same day at the same locality by the same collectors are in AMNH, CAS, MCZ, TLEr, and UASM.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Large-sized beetles, 12.3 to 13.5 mm.

Color. As in quadripennis, except antennal articles 3 and 4 infuscated only apically, and tibiae, tarsi, and palpi ferrugineous.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows rugose and sparsely punctate, disc of pronotum densely rugose and punctate, punctures moderately impressed.

Head. Frontal furrows moderately to deeply impressed. Antennal scape robust, widest about middle. Ligula with center area ellipsoid-convex and plurisetose. Mentum and submentum with accessory setae.

Prothorax. Pronotum (fig. 245) convex, flattened along center line, sides widely reflexed. Proepipleura and proepisterna as in quadripennis. Anterior tibia with anterior margin punctate, punctures sometimes forming shallow strigae.

Pterothorax. As in quadripennis, except elytra broader, costae sharper, and pubescence denser and shorter. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 227, 228, 229). Median lobe with plane of shaft rotated about 45° from plane of basal bend. Basal bend short. Apex of shaft narrowed, ridged ventrally. Ligule short, broad, truncate apically. Virga (figs. 227, 228). Female (fig. 246). Stylus broad, narrowed apically, rounded at apex.

Variation.—Intrapopulational variation occurs in the shape of the pronotum, the color of the antennal articles, and in the total size. The color of antennal articles 3 and 4 are paler in some individuals.

Flight.—These beetles have been collected repeatedly at lights throughout the range of the species.

Etymology.—Spanish, javali = wild pig; Latin, opsis = likeness; referring to the very large, broad habitus of these beetles.

Collecting notes.—D. Larson and W. Sharp have collected these beetles at margins of ponds in Texas.

Life history.—Members of this species have been collected from May to September, and in January. Teneral adults were collected in July in New Mexico. Overwintering probably takes place as an adult.

Distribution.—(Fig. 254). The range of this species extends over much of the American Southwest, from western Arizona to the Texas panhandle, and south to Brownsville. I have seen 118 specimens from the following localities:

UNITED STATES

ARIZONA: Cochise County (Douglas) UCD, UCR, (14.0 miles northeast of Douglas) UCR, (17.0 miles east of Douglas) UCR, (Guadalupe Canyon) CUNY, (3.0 miles east of Johnson) RCGr, (10.0 miles north of Paradise) TLEr, (Portal) GRNo, UCD, (South West Research Station, 5.0 miles west of Portal) AMNH, UCD, (Willcox) AMNH, UATA; Gila County (Globe) UATA; Graham County (Thatcher) UCD; Maricopa County (Gila Bend) CAS. MISSOURI: (No locality given) ISNH. NEW MEXICO: Dona Ana County (Las Cruces) CNHM, (15.0 miles north of Las Cruces) RCGr, (State College) USNM; Eddy County AMNH, (Black River, near Whites City) UWSW, (Carlsbad) UWSW, (Whites City) UWSW; Hidalgo County (Lordsburg) CNC, (Post Office Canyon, Peloncillo Mountains) UCR, (Rodeo) GRNo, UCD, UCR, (13.0 miles north of Rodeo) AMNH; Luna County (Deming) AMNH; Quay County (Tucumcari) SDSU; San Miguel County (Las Vegas) UIMI. TEXAS: Brewster County (9.0 miles north of Alpine) OSUC, (Hot Spring, Big Bend National Park) CNC; Frio

County (5.0 miles north of Dilley) UASM; Hudspeth County (9.0 miles southwest of Del City) AMNH; Kleburg County (Kingsburg) USNM; Presidio County (7.0 miles north of Marfa) RCGr; Randall County (Palo Duro State Park) UMSP; Scurry County (Snyder) TCBa; Val Verde County (Del Rio) UASM; Victoria County (Victoria) USNM.

4.6125 *Brachinus neglectus* LeConte

(Figs. 237, 238, 239, 243, 250, 255)

Brachinus neglectus LeConte, 1844:49. Lectotype, here selected, a male, MCZ red type label number unknown. This specimen is unlabelled, but stands third in a series of four specimens behind label "B. quadripennis Dejean." *Type locality*.—Georgia, as given originally by LeConte.

Diagnostic combination.—The diagnostic characters are given in the key.

Description.—Medium-sized beetles, 8.4 to 12.3 mm.

Color. Metasternum at sides, metepisterna, and abdominal sterna and terga infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and sometimes disc of pronotum rugose and sparsely punctured, punctures moderately impressed.

Head. As in *quadripennis*, except antennal scape robust, widest at middle, mentum and submentum with accessory setae.

Prothorax. As in *quadripennis*, except anterior margin of anterior tibia punctate, punctures rarely forming strigae. Pronotum (fig. 243).

Pterothorax. As in *quadripennis*.

Abdomen. As described for genus.

Genitalia. Male (figs. 237, 238, 239). Median lobe with plane of shaft rotated slightly from plane of basal bend. Basal bend long. Apex of shaft narrowed, ridged ventrally. Ligule short, truncate. Virga (figs. 237, 238). Female (fig. 250). Stylus broad basally, narrowing to almost acute apex.

Variation.—The few specimens available representing this species exhibit the usual variation in the shape of the pronotum and its macrosculpture.

Flight.—These beetles have been collected repeatedly at lights in Georgia and Florida.

Etymology.—Latin, neglectus = forgotten.

Life history.—Members of this species have been collected from March to September. Teneral adults have been collected in May in Georgia. These beetles probably overwinter as adults.

Distribution.—(Fig. 255). The range of this species extends from North Carolina to southern Florida, and west to southern Alabama. I have seen 32 specimens from the following localities:

UNITED STATES

ALABAMA: Mobile County (Mobile) CAS, (Saraland) CAS. FLORIDA: Alachua County FDAG, (Gainesville) TLEr, UMAH; Columbia County (O'Leno State Park) CUNY; Duval County (Jacksonville) CAS; Highlands County (Archbold Biology Station) PSUU; Levy County (Manatee Springs State Park) RFre; Orange County (Winter Park) MCZ; Pinellas County (Dunedin) CAS; Polk County (Lakeland) UMAH; County unknown (Guntown) ANSP. GEORGIA: Charlton County (Okefenokee Swamp, Billy's Island) CUNY; Chatham County (Savannah) CAS; Thomas County (Thomasville)

ANSP, MCZ. NORTH CAROLINA: Moore County (Southern Pines) CAS.
SOUTH CAROLINA: (No locality given) MCZ.

Figs. 226, 230. Pronotum, right half, dorsal aspect. 226. Brachinus kavanaughi new species, Superior, Colorado. 230. Brachinus quadripennis Dejean, Archbold Research Station, Florida. Figs. 227-229, 231-242. Male genitalia. 227. Brachinus javalinopsis new species, 32.0 miles east of Douglas, Arizona, ventral aspect. 228. Lateral aspect of same. 229. Dorsal aspect of same. 231. Brachinus kavanaughi new species, 6.9 miles north of Golden, Colorado, ventral aspect. 232. Lateral aspect of same. 233. Dorsal aspect of same. 234. Brachinus mexicanus Dejean, 0.9 miles northeast of Cedar Springs, California, ventral aspect. 235. Lateral aspect of same. 236. Dorsal aspect of same. 237. Brachinus neglectus LeConte, Guntown, Florida, ventral aspect. 238. Lateral aspect of same. 239. Dorsal aspect of same. 240. Brachinus quadripennis Dejean, Grand Coulee, Washington, ventral aspect. 241. Lateral aspect of same. 242. Dorsal aspect of same. Accompanying scale lines equal 1.0 mm.

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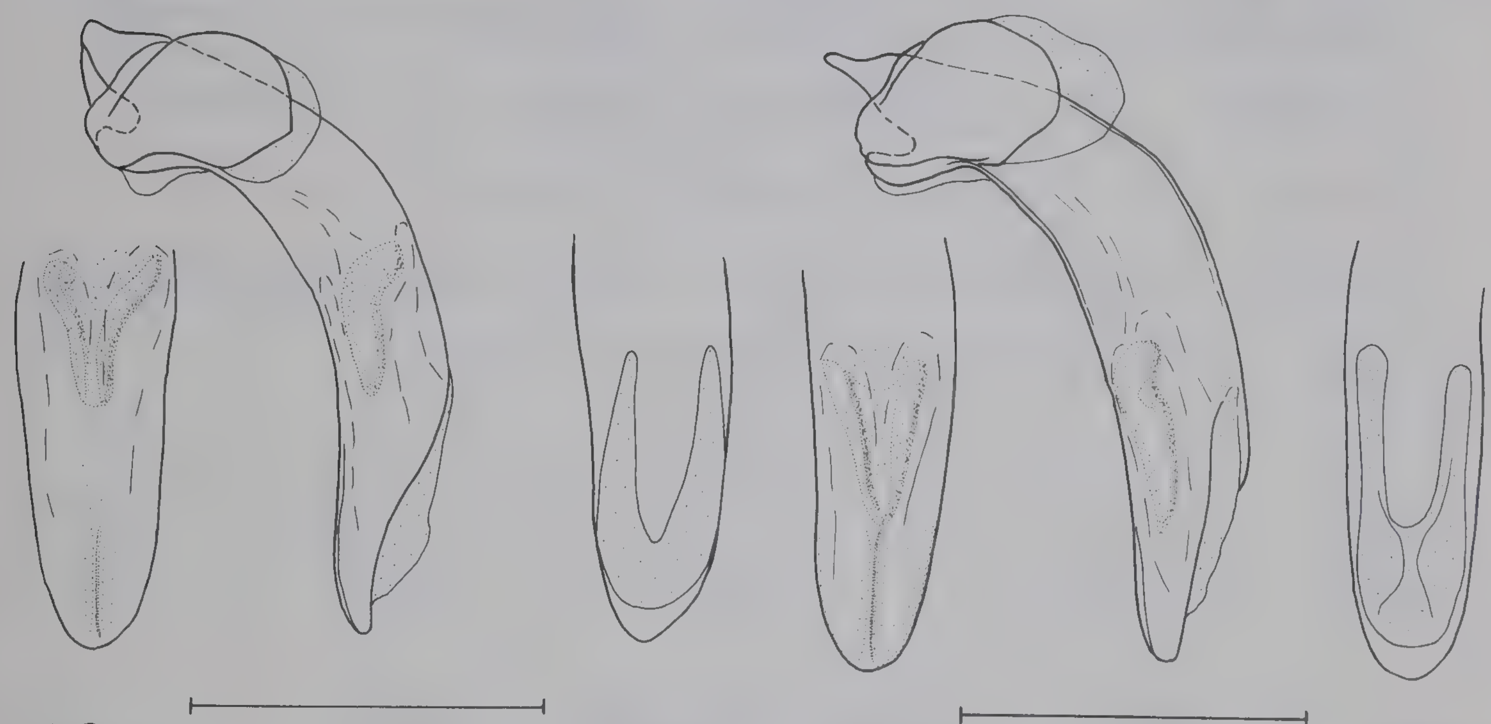

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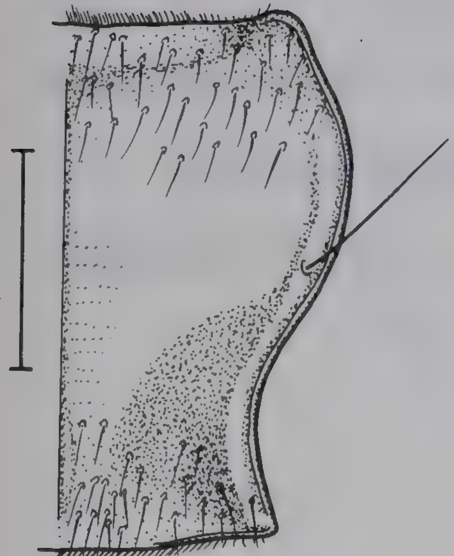
Figs. 243-245. Pronotum, right half, dorsal aspect. 243. _Brachinus neglectus_ LeConte, Southern Pines, North Carolina. 244. _Brachinus mexicanus_ Dejean, Temecula, California. 245. _Brachinus javalinopsis_ new species, Victoria, Texas. Figs. 246-250. Right stylus of female ovipositor, ventral aspect. 246. _Brachinus javalinopsis_ new species, 15.0 miles north of Las Cruces, New Mexico. 247. _Brachinus quadripennis_ Dejean, Smyrna, Washington. 248. _Brachinus mexicanus_ Dejean, Temecula, California. 249. _Brachinus kavanaughi_ new species, Superior, Colorado. 250. _Brachinus neglectus_, Jacksonville, Florida. Fig. 251. Geographical distribution map of _Brachinus quadripennis_ Dejean. Accompanying scale lines equal 1.0 mm.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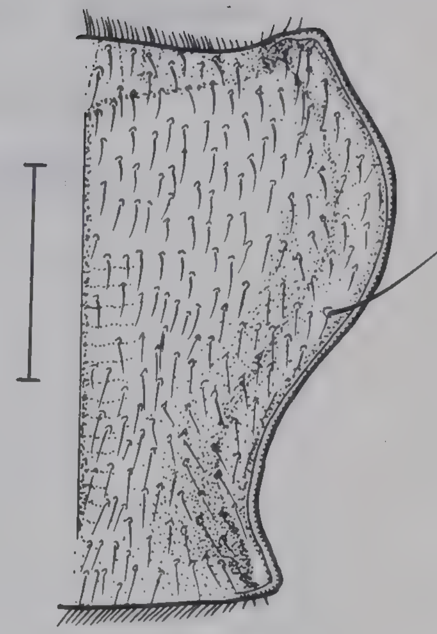
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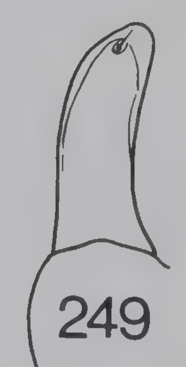
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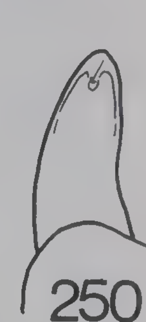
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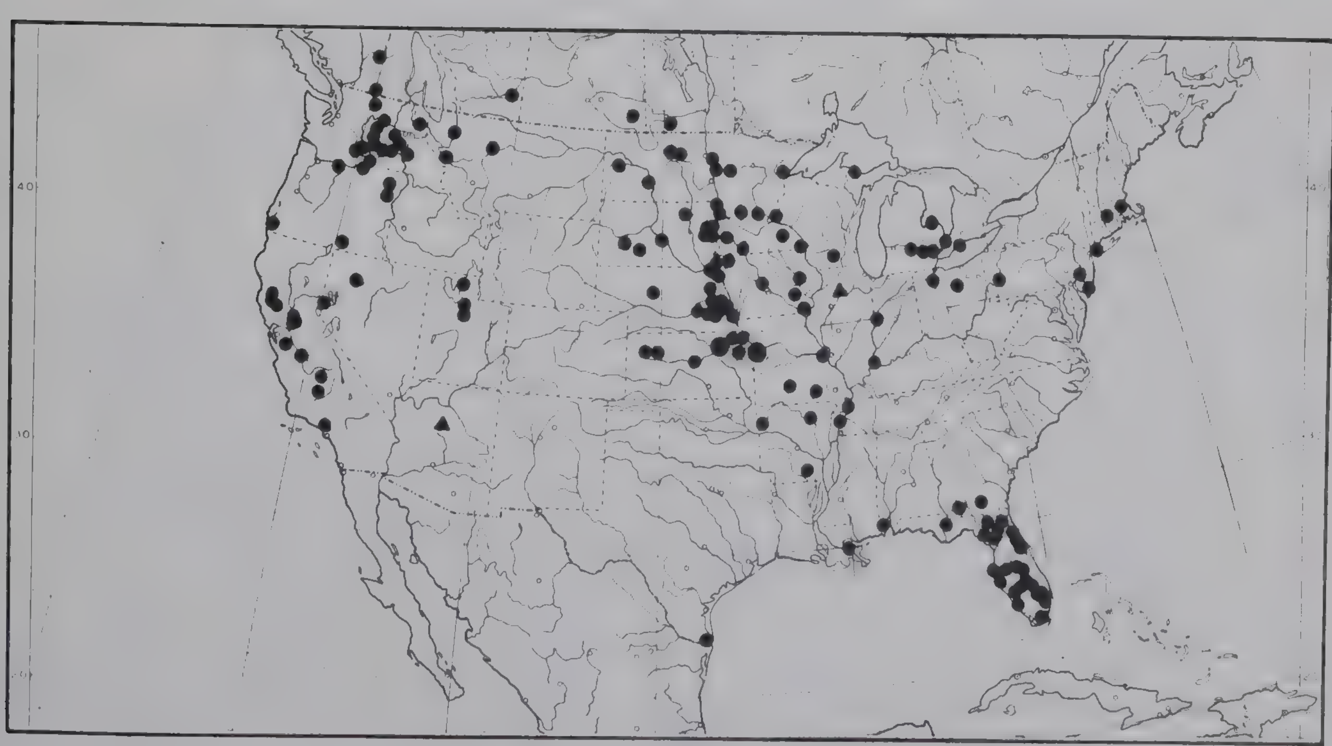
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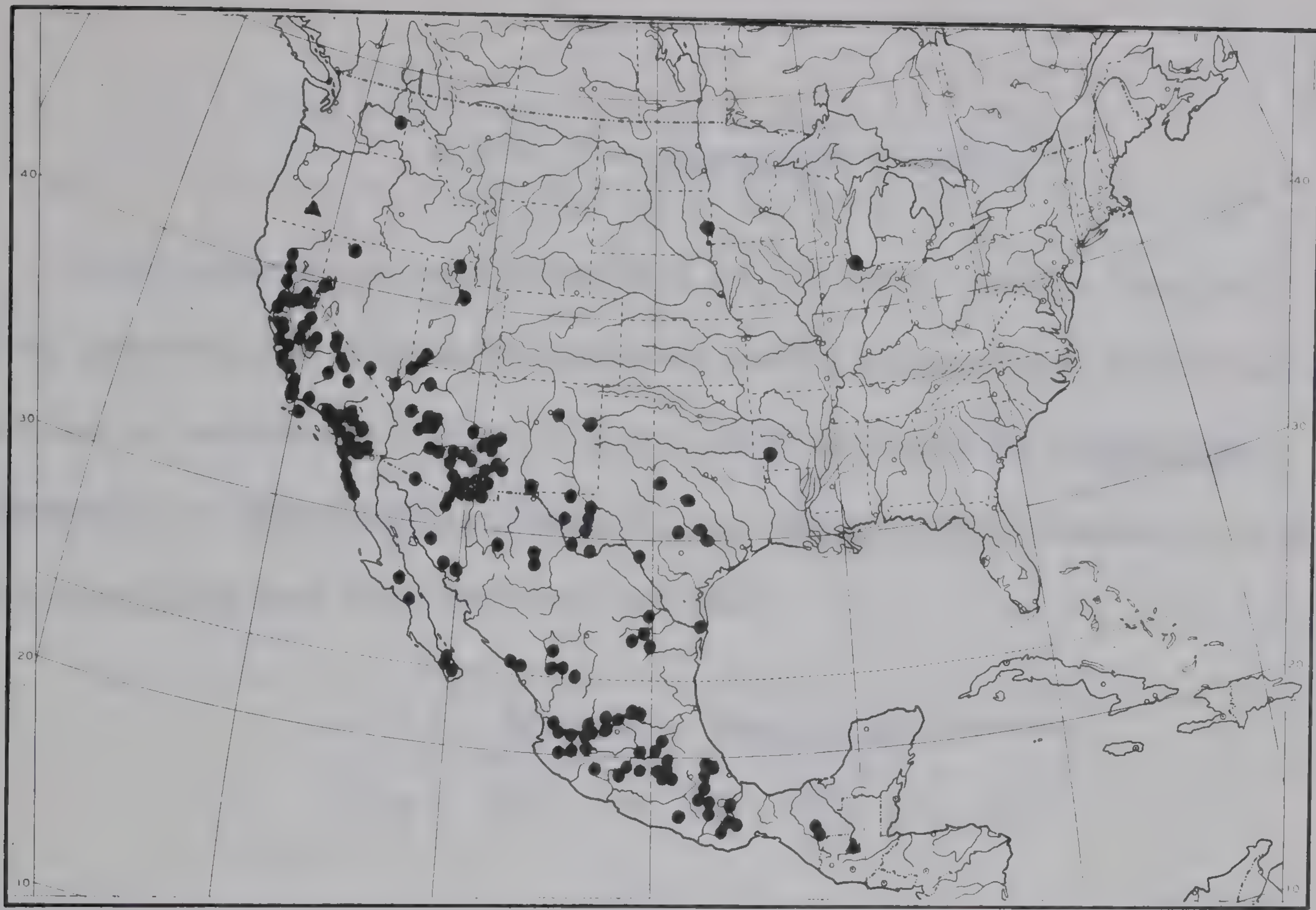
Figs. 252-255. Geographical distribution maps. 252. *Brachinus mexicanus* Dejean. 253. *Brachinus kavanaughi* new species. 254. *Brachinus javalinopsis* new species. 255. *Brachinus neglectus* LeConte.



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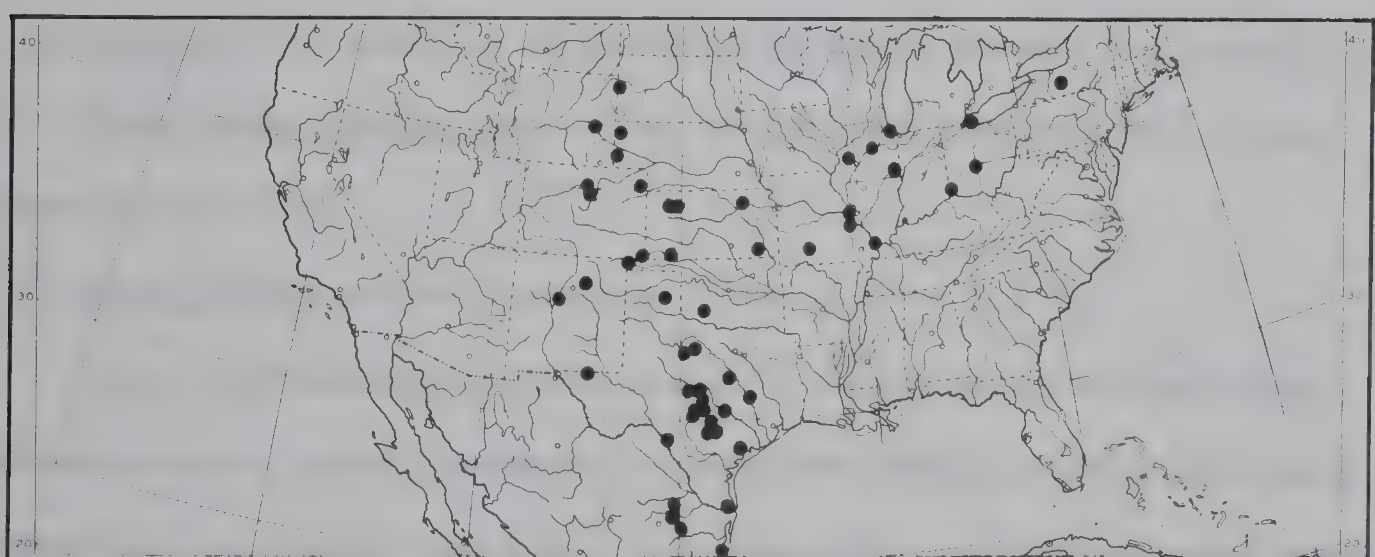

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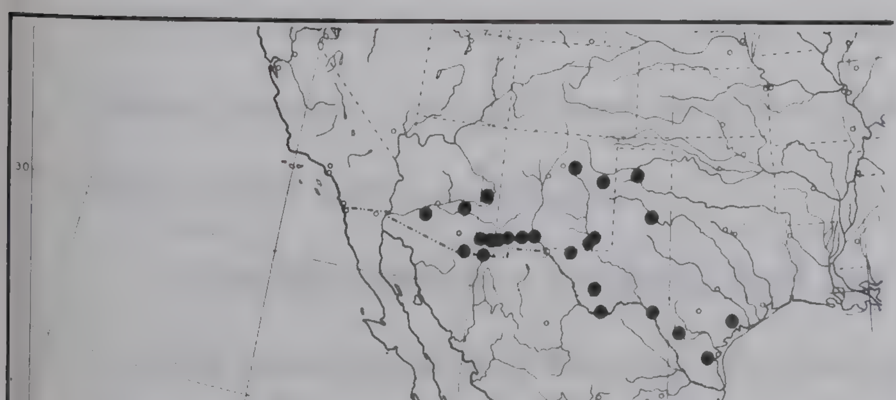

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4.613 The phaeocerus subgroup

This subgroup is characterized as follows: median lobe with long narrow apex, elytra bright blue with a contrasting black suture, and outer antennal articles black. Four species, B. phaeocerus Chaudoir, B. azureipennis Chaudoir, B. consanguineus Chaudoir, and B. imporcitis new species, are included.

4.6131 Brachinus phaeocerus Chaudoir

(Figs. 257, 258, 259, 265, 275, 279)

Brachinus phaeocerus Chaudoir, 1868:300. Lectotype, here selected, a male, MHNP, labelled "Tejas" and "Ex Museo Chaudoir." Type locality.—Texas, as originally given by Chaudoir's label.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Small-sized beetles, 7.2 to 8.1 mm.

Color. Antennal articles 3 and 4, mesepimera, metepisterna, metasternum at sides, abdominal sterna and terga, tibiae and tarsi infuscated to black. Antennal articles 5-11, and metasternal process (between middle coxae), usually darkly infuscated. Female somites 7 and 8, and male somites 8 and 9, and remainder of beetle, ferrugineous. Dorsal surface and epipleura of elytra bright blue with black sutural margins.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and surface of pronotum densely rugose and punctate, punctures moderately deeply impressed.

Head. Frontal furrows moderately deeply impressed. Antennal

scape robust, but nearly cylindrical. Ligula with sclerotized center area with two lateral rows of three setae per row. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 265) slightly convex, flattened along center line, sides slightly reflexed. Proepipleura glabrous. Proepisterna with a few setae both anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior surface strigose.

Pterothorax. Elytra moderately long, narrow, moderately costate. Humeral angle square to prominent. Costae and depressions pubescent. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 257, 258, 259). Median lobe with plane of shaft rotated slightly from plane of basal bend. Basal bend moderately long. Apex of shaft narrowed to apex, elongate. Ligule short, narrow, truncate. Virga (figs. 257, 258). Female (fig. 275). Stylus narrow, tapering to acute apex.

Variation.—Intrapopulational variation occurs in the shape of the pronotum, and degree of infuscation of the outer antennal articles.

Flight.—G. E. Ball collected these beetles at lights in Big Bend National Park, Texas.

Etymology.—Greek, *phaios* = dusky brown; *keros* = horn; referring to the infuscated antennae of these beetles.

Collecting notes.—G. E. Ball collected these beetles in *Carex* marshes at Colorado Springs; and my wife and I collected them with *B. kavanaughi* specimens along streams near Golden, Colorado.

Life history.—Members of this species have been collected from

February to September. Teneral adults were collected in May in Texas and in June in Oklahoma. Overwintering probably takes place as an adult.

Distribution.--(Fig. 279). The range of this species extends from Nebraska south to Chihuahua, Mexico. The distribution seems to be continuous to eastern Kansas, but a great discontinuity lies between Kansas and G. E. Ball's New York record. Ball recorded the capture of these specimens in his collecting notes, so there is no doubt that he took them alive near Ithaca, New York. To the west, these beetles extend to the east flank of the Chiricahua Mountains and the White Mountains of Arizona. They also range down the Gila River system into Arizona where they apparently hybridize with B. imporcitis new species. I have seen 213 specimens from the following localities:

MEXICO

CHIHUAHUA: (San Rafael) AMNH.

UNITED STATES

ARIZONA: Cochise County (Cave Creek Canyon, Portal) TCBa. COLORADO: Boulder County (Bear Creek Canyon) CArm, (Cole Creek, Marshall Lake Area) CArm, (Cole Creek, Plainview) CArm, (Cole Creek, east of Superior) CArm, (Four Mile Creek) CArm, (Left Hand Creek, Lyons) CArm, (Red Gulch, Lyons) CArm, (Rocky Flats Reservoir) CArm, (South Saint Vrain, east of Lyons) CArm; El Paso County (near Colorado Springs) UASM; Jefferson County (2.0 miles north of Golden) DHKa, TLEr; Weld County (Greeley) USNM. KANSAS: Douglas County (Lawrence) MCZ; Riley County (Manhattan) KSU. NEBRASKA: Banner County (Glen Rock Canyon) UNLN. NEW MEXICO: Catron County (Cooney Canyon, 10.0

miles east of Alma) UASM, (San Francisco Creek, 26.1 miles north of Glenwood) UASM; Grant County (18.0 miles north of Mimbres) TLEr, (Silver City) MCZ; Taos County (Rio Grande River, near Velarde) UASM. NEW YORK: Tompkins County (Ithaca) UASM. OKLAHOMA: Alfalfa County (No locality given) OSUS, Comanche County (Wichita National Forest) CAS; Jackson County (No locality given) CAS. TEXAS: Blanco County (Round Mountain) OUCO, (2.0 miles south of Round Mountain) UASM; Brewster County (Alpine) CAS, (Big Bend National Park) UASM; Culberson County (2.5 miles east of Nickel Creek Station) CNHM; Eastland County (No locality given) UMSP; Hemphill County (Canadian) USNM; Kerr County (10.0 miles north of Kerrville) UMSP; Taylor County (25.0 miles southwest of Abilene) CNHM; Travis County (Austin) WSUP.

4.6132 Brachinus imporcitis new species

(Figs. 32, 261, 262, 263, 264, 274, 278)

Type locality.—Pinal Creek, Globe, Gila County, Arizona.

Type specimens.—The holotype male and allotype female are in CUNY. Both were collected at the type locality by A. and H. Dietrich on May 8, 1953 at an elevation of 5,500 feet. Three paratypes collected at various localities on various dates are in AMNH, CAS MCZ, TLEr, and UASM.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.--Small-sized beetles, 7.0 to 8.9 mm.

Color. Apex of antennal articles 3 and 4, metepisterna, and abdominal sterna and terga infuscated, otherwise ferrugineous.

Outer antennal articles usually dark. Dorsal surface and epipleura of elytra bright blue, with black sutural margins.

Microsculpture. As described for genus.

Macrosculpture. As in phaeocerus.

Head. As in phaeocerus, except antennal scape widest about middle.

Prothorax. As in phaeocerus, except proepisterna glabrous. Pronotum (fig. 261).

Pterothorax. As in phaeocerus, except humeri narrow, sloping, and wings reduced outside stigma (fig. 32).

Abdomen. As described for genus.

Genitalia. Male (figs. 262, 263, 264). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend short. Apex of shaft narrowed to apex, slightly curved dorsally. Ligule short, broad, rounded apically. Virga (figs. 262, 263). Female (fig. 274). Stylus narrow, tapering to narrowly rounded apex.

Variation.—Intrapopulational variation occurs in the shape of the pronotum, and total size, otherwise the characters are constant.

Flight.—These beetles have never been recorded in flight and it is doubtful that they can fly.

Etymology.—Latin, Imporcitis = god of plowing; referring to the furrow-like costae of the elytra.

Life history.—Members of this species have been collected from May to September, and in January. Teneral adults have been collected in May at Bumble Bee, Arizona. Overwintering probably takes place as an adult.

Distribution.—(Fig. 278). The range of this species is confined

to Arizona. In the San Simon Valley these beetles occur along the Gila River system where they apparently hybridize with B. phaeocerus. I have seen 81 specimens from the following localities:

UNITED STATES

ARIZONA: Cochise County (Chiricahua Mountains) UATA, USNM, (Chiricahua National Monument) CAS, (South West Research Station, 5.0 miles west of Portal) AMNH; Gila County (Globe) KSU, UMAH, (Middle Pioneer Camp, Pinal Mountains) UMNH, (Pinal Creek, Globe) CUNY, (base of Pinal Mountains) CAS, UATA, (Roosevelt Lake) UMAH; Greenlee County (Clifton) CAS; Pima County (Tucson) AMNH; Yavapai County AMNH, (Bumble Bee) CAS, (Crown King) CAS, (Monte Crypta Mine) CUNY, (Potter Creek, Prescott) CAS, (Prescott) CAS, MCZ, USNM; County unknown (Superstition Mountains) UATA.

4.6133 Brachinus azureipennis Chaudoir
(Figs. 260, 269, 270, 271, 273, 276)

Brachynus azureipennis Chaudoir, 1876:75. Lectotype, here selected, a male, MHNP, labelled "Matamoros" and "Ex Museo Chaudoir." Type locality.—Matamoros, Puebla, Mexico, as originally given by Chaudoir.

Diagnostic combination.—The black palpi, antennae, tibiae and tarsi, plus the metallic blue luster of the venter will separate these beetles from all others of the genus in North and Middle America.

Description.—Medium-sized beetles, 7.8 to 10.3 mm.

Color. Palpi, antennal articles 2-11, tibiae, tarsi, and elytra near suture, black. Metepisterna, metasternum at sides, and abdominal

sterna and terga black with metallic blue luster, otherwise ferrugineous. Dorsal surface and epipleura of elytra bright blue with black sutural margins.

Microsculpture. As described for genus.

Macrosculpture. As in phaeocerus.

Head. As in phaeocerus, except ligula with only two or three setae apically.

Prothorax. As in phaeocerus, except proepipleura and proepisterna completely pubescent.

Pterothorax. As in phaeocerus.

Abdomen. As described for genus.

Genitalia. Male (figs. 269, 270, 271). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend short. Apex of shaft narrow and elongate. Ligule moderately long, narrow, tapering to apex. Virga (figs. 269, 270). Female (fig. 273). Stylus broad at base, narrowing to acute apex.

Variation.—Intrapopulational variation occurs in the shape of the pronotum, body size and in the brightness of blue color of the elytra.

Flight.—The flight of these beetles has been recorded by F. G. Werner in Jalisco, Mexico.

Etymology.—French, azur = blue; Latin, pennis = wing; referring to the bright blue color of the elytra of these beetles.

Collecting notes.—G. E. Ball and D. R. Whitehead collected these beetles in a wet pasture beneath stones near El Mogote, Guerrero, Mexico. There was no water in the near vicinity.

Life history.—Members of this species have been collected in

January and February, July and August, and October, but no teneral adults were seen.

Distribution.—(Fig. 276). The range of this species extends from southern Arizona south to Guerrero, Mexico. I have seen 107 specimens from the following localities:

MEXICO

AGUASCALIENTES: (4.0 miles southwest of Aguascalientes) AMNH; (15.0 miles west of Pabellon) UMAH. CHIHUAHUA: (Madera) AMNH; (Primavera) AMNH; (Salaices) AMNH; (San Jose Babicora) AMNH. DISTRITO FEDERAL: (Temascaltepec) CAS. DURANGO: (Durango) AMNH; (15.0 miles west of Durango) CNC; (6.0 miles northeast of El Salto) AMNH; (Otinapa) AMNH. GUERRERO: (2.0 miles north of El Mogote) UASM. JALISCO: (Guadalajara) AMNH; (16.0 kilometers west of Jalostotitlan) MCZ. MEXICO: (4.3 miles north of Ixtapan de La Sal) UASM. MICHOACAN: (Tuxpan) RCGr. SAN LUIS POTOSI: (Puente La Parada, 7.5 miles northwest of Mexquitic) UASM. ZACATECAS: (Presa Choquen) JHen.

UNITED STATES

ARIZONA: Cochise County (San Pedro River, near Palominas) UASM, (South West Research Station, 5.0 miles west of Portal) AMNH; Santa Cruz County (Canelo) UATA.

4.6134 Brachinus consanguineus Chaudoir

(Figs. 256, 266, 267, 268, 272, 277)

Brachynus consanguineus Chaudoir, 1876:76. Lectotype, here selected, a male, MHNP, labelled "Ex Museo Chaudoir" and standing first of two specimens in front of box label "consanguineus Chaudoir, Mexique, Toluca Boucardi." Type locality.--Toluca, Mexico,

as originally given by Chaudoir.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 10.2 mm.

Color. Antennal articles 3-11, metepisterna, and abdominal sterna and terga infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra bright blue with black sutural margins.

Microsculpture. As described for genus.

Macrosculpture. As in *phaeocerus*, except punctures finer.

Head. As in *phaeocerus*, except frontal furrow more deeply impressed, antennal scape widest apically, and ligula plurisetose.

Prothorax. As in *phaeocerus*, except sides widely reflexed, and proepipleura and proepisterna pubescent. Pronotum (fig. 256).

Pterothorax. As in *phaeocerus*.

Abdomen. As described for genus.

Genitalia. Male (figs. 266, 267, 268). Median lobe with plane of shaft rotated slightly from plane of basal bend. Basal bend short. Apex of shaft elongate, tubular. Ligule very short, truncate. Virga (figs. 266, 267). Female (fig. 272). Stylus narrow, longer than in *phaeocerus*, narrowed apically.

Variation.—Too few specimens are known to evaluate geographic variation.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Latin, *consanguineus* = related by blood; probably referring to the similarity of these beetles to other members of the genus.

Life history.—Members of this species have been collected in

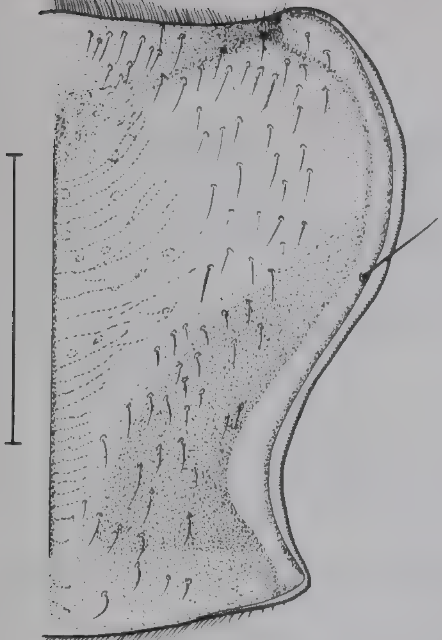
August and December, but no teneral adults were seen.

Distribution.—(Fig. 277). The range of this species extends from Sonora to Guerrero along the western side of Mexico. I have seen four specimens from the following localities:

MEXICO

GUERRERO: (Rio Papagayo, 41.4 miles north of Acapulco) UASM. SINALOA: (28.0 miles east of Villa Union) CNC. SONORA: (Rio Mayo, Caramechi) CAS.

Figs. 256, 260, 261, 265. Pronotum, right half, dorsal aspect. 256. Brachinus consanguineus Chaudoir, Rio Papagayo, Guerrero, Mexico. 260. Brachinus azureipennis Chaudoir, 2.0 miles north of El Mogote, Guerrero, Mexico. 261. Brachinus imporcitis new species, Globe, Arizona. 265. Brachinus phaeocerus Chaudoir, 25.0 miles southwest of Abilene, Texas. Figs. 257-259, 262-264, 266-271. Male genitalia. 257. Brachinus phaeocerus Chaudoir, 25.0 miles southwest of Abilene, Texas, ventral aspect. 258. Lateral aspect of same. 259. Dorsal aspect of same. 262. Brachinus imporcitis new species, Globe, Arizona, ventral aspect. 263. Lateral aspect of same. 264. Dorsal aspect of same. 266. Brachinus consanguineus Chaudoir, Rio Mayo, Sonora, Mexico, ventral aspect. 267. Lateral aspect of same. 268. Dorsal aspect of same. 269. Brachinus azureipennis Chaudoir, 2.0 miles north of El Mogote, Guerrero, Mexico, ventral aspect. 270. Lateral aspect of same. 271. Dorsal aspect of same. Accompanying scale lines equal 1.0 mm.



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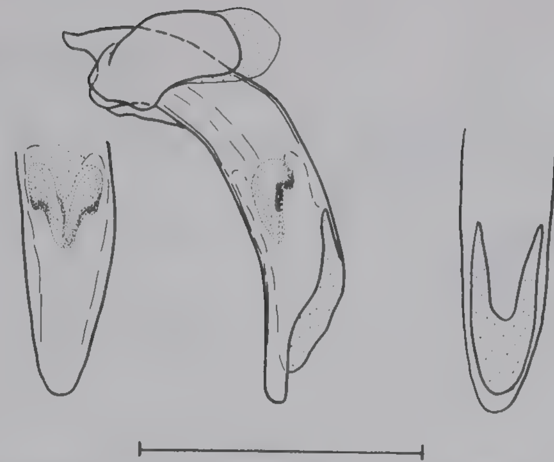

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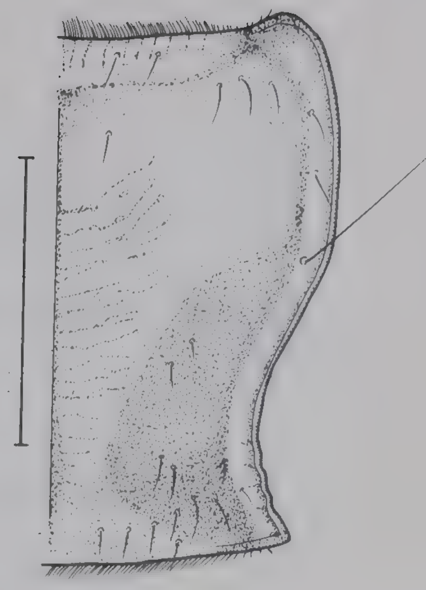

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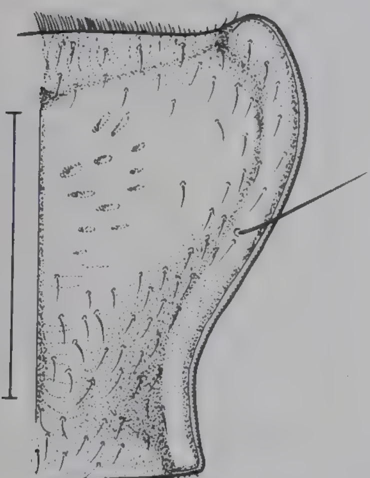

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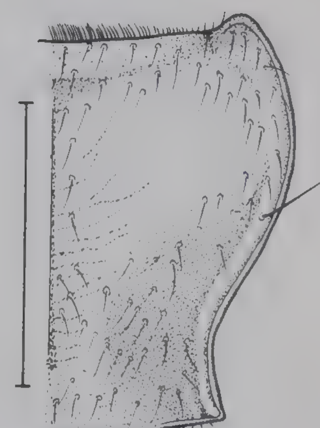

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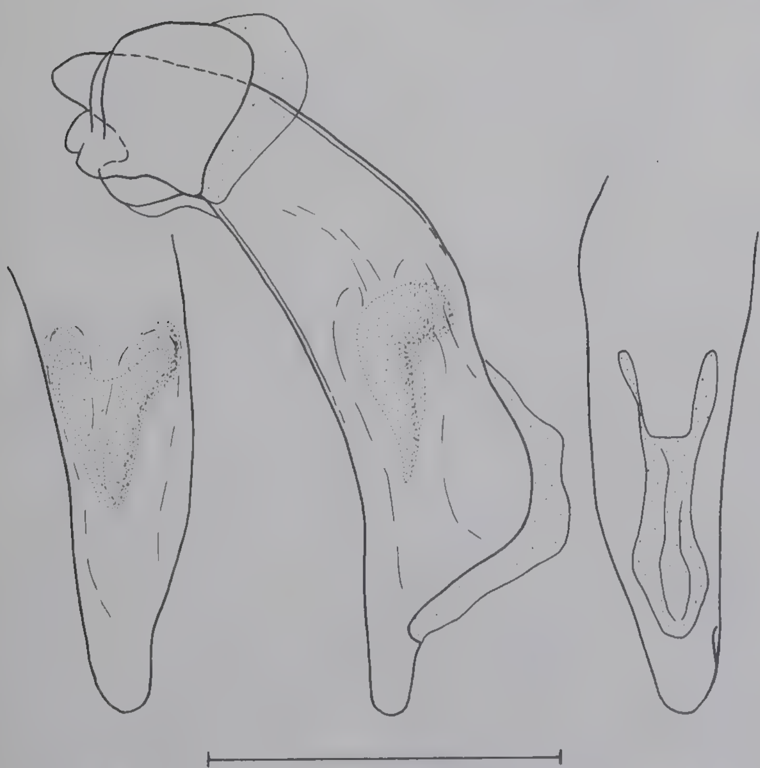

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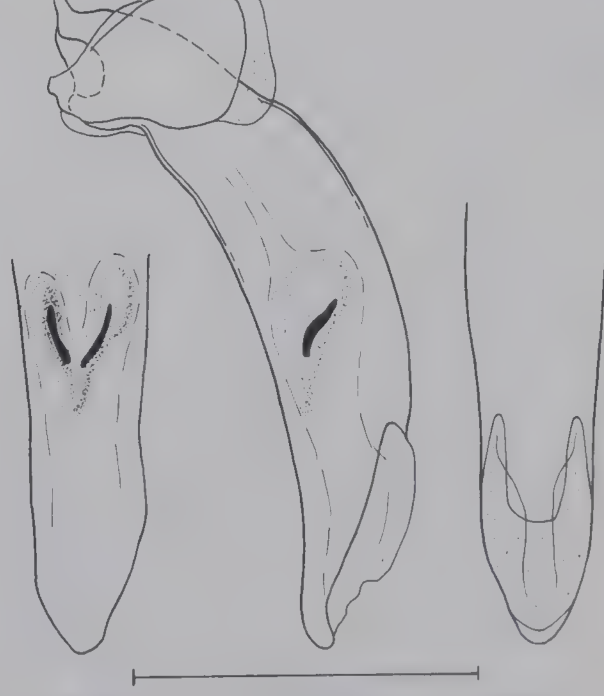

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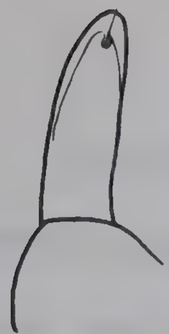
Figs. 272-275. Right stylus of female ovipositor, ventral aspect. 272. _Brachinus consanguineus_ Chaudoir, 41.4 miles north of Acapulco, Guerrero, Mexico. 273. _Brachinus azureipennis_ Chaudoir, 2.0 miles north of El Mogote, Guerrero, Mexico. 274. _Brachinus imporcitis_ new species, Pinal Creek, Arizona. 275. _Brachinus phaeocerus_ Chaudoir, 25.0 miles south of Abilene, Texas. Figs. 276-279. Geographical distribution maps. 276. _Brachinus azureipennis_ Chaudoir. 277. _Brachinus consanguineus_ Chaudoir. 278. _Brachinus imporcitis_ new species. 279. _Brachinus phaeocerus_ Chaudoir. Accompanying scale line equals 1.0 mm.



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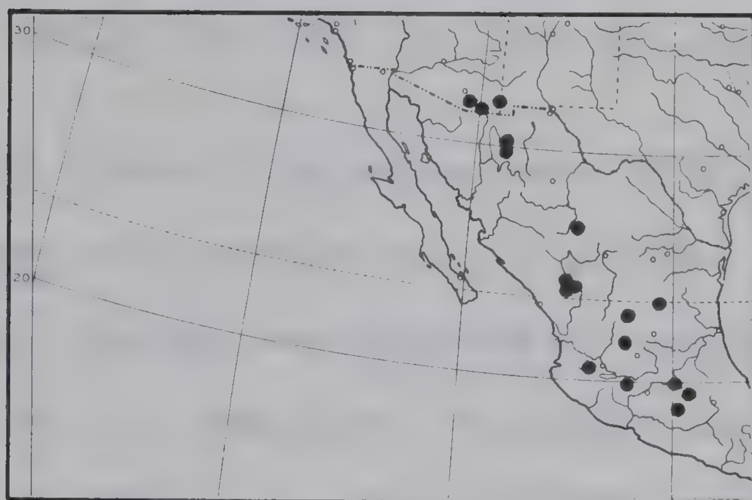

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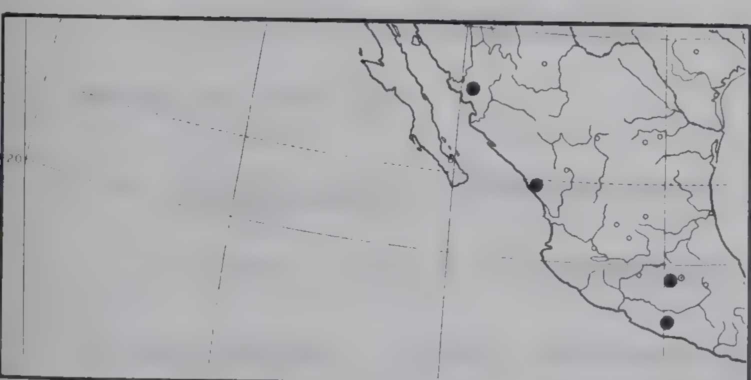

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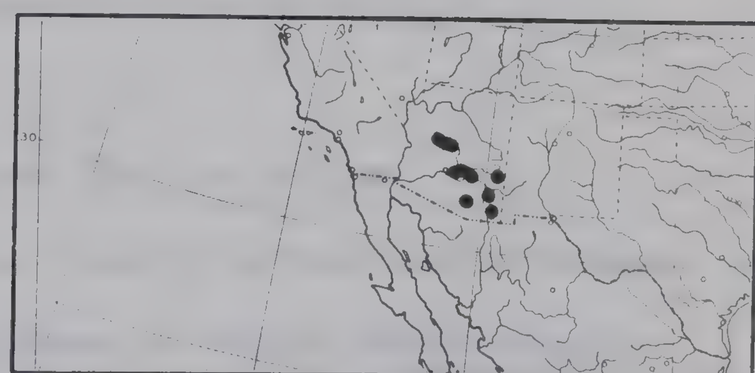

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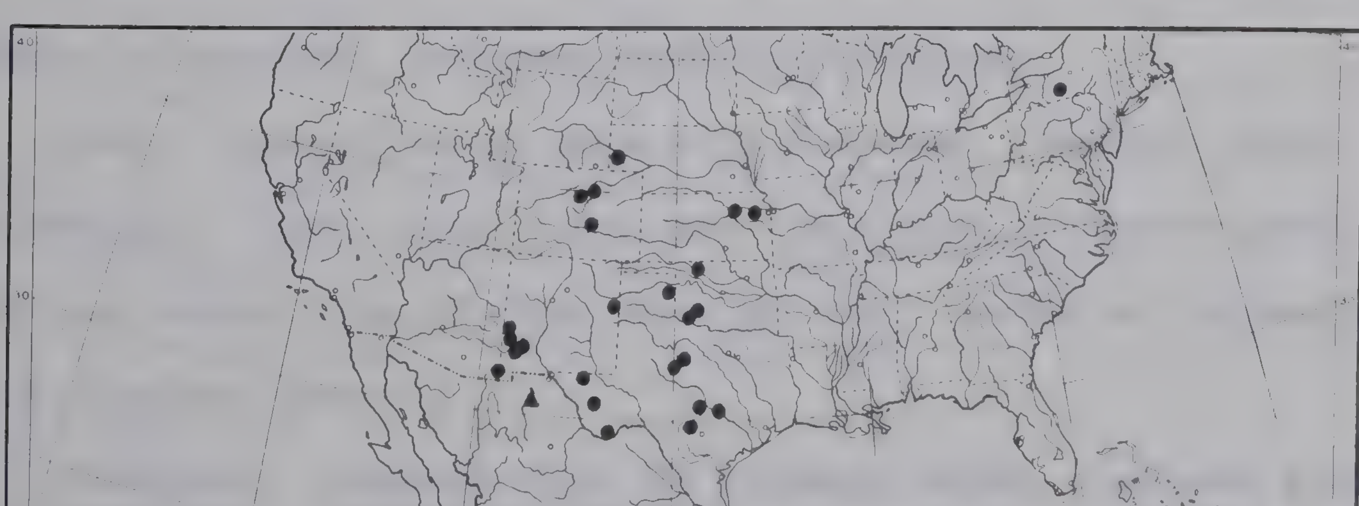

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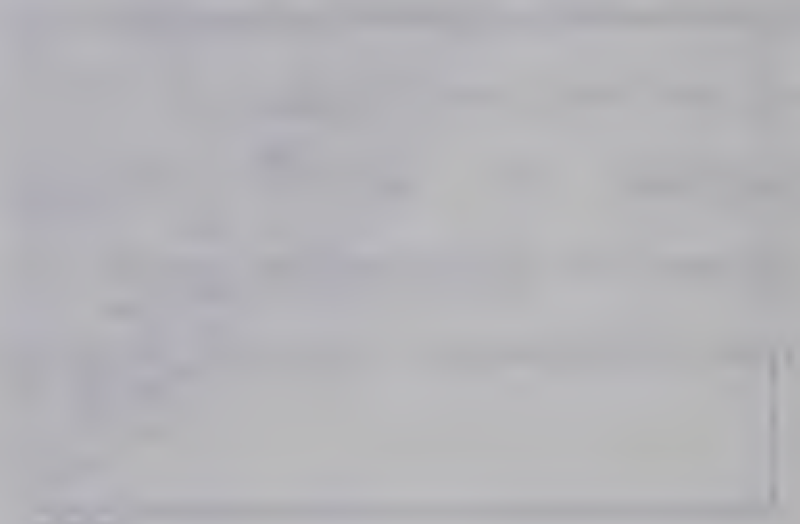

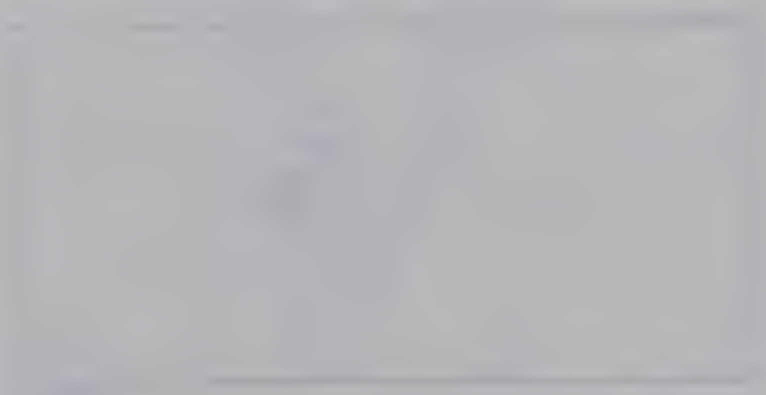

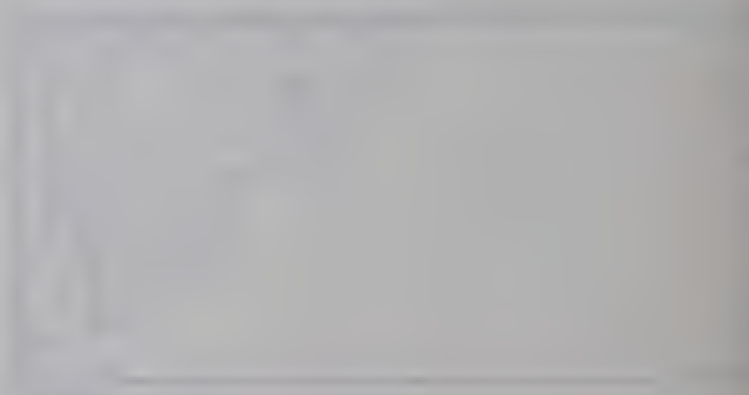

4.614 The oaxacensis subgroup

This group is characterized as follows: virga elongate and strongly chitinized, lateral pronotal setae lacking, and highly raised elytral costae. One species, *B. oaxacensis* new species, is included.

4.6141 *Brachinus oaxacensis* new species
(Figs. 280, 290, 291, 292, 297, 300)

Type locality.—Twenty-five smiles south of Mitla, Oaxaca, Mexico.

Type specimens.—The holotype male is in ISUA. The allotype female is in UASM. The male was collected at the type locality on January 4, 1956, by J. C. Schaffner. The female was collected by G. E. Ball and D. R. Whitehead on March 3, 1966 along the Rio Atoyac, near Juchatengo, Oaxaca. One paratype is in CPBo, JHen, and UCD.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 10.2 to 10.6 mm.

Color. Sides of abdominal sterna slightly infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra bright bluish-green.

Macrosculpture. Frontal furrows and surface of pronotum finely rugose and punctate, punctures moderately impressed.

Head. Frontal furrows moderately impressed. Antennal scape cylindrical. Ligula with sclerotized center area ellipsoid-convex with two lateral rows of three setae per row. Mentum and submentum with accessory setae.

Prothorax. Pronotum (fig. 28) slightly convex, flattened along

center line, sides slightly reflexed. Lateral setae absent. Proepipleura and proepisterna with numerous setae throughout their length. Anterior tibia with anterior surface strigose.

Pterothorax. Elytra elongate, broad, strongly costate. Humeral angle square. Depressions with numerous setae, costae smooth. Depression 1 with erect depression setae twice as long as elytral pubescence. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (Figs. 290, 291, 292). Median lobe with plane of shaft rotated from plane of basal bend about 45°. Basal bend short. Apex of shaft broadly rounded. Ligule short, broad, rounded apically. Virga (figs. 290, 291). Female (figs. 297). Stylus narrow, parallel-sided, rounded apically.

Variation.—Too few specimens are known to evaluate geographic variation.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Oaxaca, the place where the types are from; Latin, ensis = place, locality or county.

Collecting notes.—G. E. Ball and D. R. Whitehead collected one specimen of this species from under a rock at the edge of the Rio Atoyac, Oaxaca, Mexico.

Life history.—Members of this species have been collected in March, May, and December, but no teneral adults have been seen.

Distribution.—(Fig. 300). The range of this species extends from Sonora to Oaxaca. I have seen five specimens from the following localities:

MEXICO

GUERRERO: (Cacahuamilpa) CPBo, JHen. OAXACA: (Rio Atoyac, near Juchatengo) UASM; (25.0 miles south of Mitla) ISUA. SONORA: (10.0 miles southeast of Alamos) UCD.

4.615 The patruelis subgroup

The members of this subgroup are characterized by their short median lobe, with three ligules, and their narrow sloping humeri. One species, B. patruelis LeConte, is included.

4.6151 Brachinus patruelis LeConte
(Figs. 282, 284, 285, 286, 296, 301)

Brachinus patruelis LeConte, 1844:50. Lectotype, here selected, a female, MCZ red type label number 5842, further labelled with a pink disc and "B. conformis Dej. patruelis LeC." Type locality.—New York, as originally given by LeConte.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Small-sized beetles, 5.7 to 8.3 mm.

Color. Antennal articles 3 and 4, mesepisterna, metepisterna, metasternum at sides, and abdominal sterna and terga infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows rugose, sparsely punctate. Surface of pronotum sparsely punctate, punctures barely impressed.

Head. Frontal furrows moderately impressed. Antennal scape robust, widest at middle. Ligula with sclerotized center area

ellipsoid-convex with two apical setae. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 282) convex, slightly flattened along center line, sides moderately reflexed. Proepipleura glabrous. Proepisterna with a few setae both anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior surface strigose.

Pterothorax. Elytra short, weakly costate. Humeral angle narrow, sloped. Costae and depressions pubescent. Metasternum short, its length less than diameter of middle coxa. Wings reduced outside stigma, as in figure 32.

Abdomen. As described for genus.

Genitalia. Male (figs. 284, 285, 286). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend short. Median lobe very short and robust. Apex of shaft broadly rounded. Ligule short, broad, with two lateral accessory ligules. Virga (figs. 284, 285). Female (fig. 296). Stylus short, narrow, narrowly rounded apically.

Variation.—Intrapopulational variation occurs in the shape of the pronotum, body size, and in the prominence of the humeri.

Flight.—The flight of these beetles has not been recorded, and it is probable that they cannot fly.

Etymology.—Latin, patruelis = cousin, kin; referring probably to the similar habitus of these beetles to other *Brachinus* species.

Life history.—Members of this species have been collected from April to September. Teneral adults were collected in May in Massachusetts.

Distribution.—(Fig. 301). The range of this species extends from

Massachusetts south to New Jersey. Western populations are in Michigan and Illinois. I have seen 61 specimens from the following localities:

UNITED STATES

CONNECTICUT: New London County (Old Lyme) CAS. ILLINOIS: (No locality given) ISNH. MASSACHUSETTS: Bristol County (Fall River) CAS; Middlesex County (Framingham) CAS, UNLN, (Newton) MCZ; Norfolk County (Brookline) MCZ; Plymouth County (Marion) MCZ; Suffolk County (Boston) CAS, (Dorchester) MCZ, UMAH; County unknown (Blue Hills) ISUA, USNM, (Forest Hills) USNM, (Freetown) CAS. MICHIGAN: Wayne County (Detroit) CAS. NEW JERSEY: Bergen County (Fort Lee) CAS; Burlington County (Atsion) CAS; Morris County (Towaco) USNM; Warren County (Great Piece Meadows) AMNH. NEW YORK: New York County (Staten Island) CAS, (Yonkers) CNHM; Suffolk County (Southold) CUNY; County unknown (Newtown, Long Island) CAS.

4.616 The conformis subgroup

This subgroup is characterized as follows: median lobe small, narrow, and chisel-shaped, and stylus of female ovipositor elongate and narrow. One species, B. conformis Dejean, is included.

4.6161 Brachinus conformis Dejean
(Figs. 283, 287, 288, 289, 298, 302)

Brachinus conformis Dejean, 1831:427. Lectotype, here selected, a female, MHNP, labelled "conformis m. in Amer. bor." on green paper, "LeConte" and "Ex Museo Chaudoir" on white paper.

Type locality.—North America, as originally given by Dejean,

but herewith restricted to Florida.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Small-sized beetles, 5.0 to 8.0 mm.

Color. Terminal palpal articles, antennal articles 2, 3, and 4, metepisterna, and abdominal sterna and terga infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and surface of pronotum punctate and microrugose, punctures barely impressed.

Head. Frontal furrows shallowly impressed. Antennal scape robust, widest at middle. Ligula with sclerotized center area ellipsoid-convex with two lateral rows of three setae per row. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 283) convex, slightly flattened along center line, sides barely reflexed. Proepipleura and proepisterna pubescent both anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior surface strigose.

Pterothorax. Elytra elongate, narrow, moderately costate. Humeral angle square. Costae smooth, glabrous on disc, depressions between costae pubescent. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 287, 288, 289). Median lobe with plane of shaft barely rotated from plane of basal bend. Basal bend short. Shaft straight, narrow, flattened, apex narrowly rounded. Ligule short, narrowed apically, rounded at apex. Virga (figs. 287, 288). Female (fig. 298). Stylus elongate, narrow, rounded apically.

Variation.—Too few specimens are known to evaluate geographic variation.

Flight.—These beetles have been collected at lights repeatedly in Florida.

Etymology.—Latin, conformis = similar; referring to the similarity between these beetles and those of other species in the genus.

Life history.—Members of this species have been collected in May, June, and November, but no teneral adults have been seen.

Distribution.—(Fig. 302). The range of this species extends from middle Florida to northern Florida. I have seen 34 specimens from the following localities:

UNITED STATES

FLORIDA: Alachua County (Gainesville) USNM; Duval County (Jacksonville) OUCO; Highlands County (Archbold Biology Station) PSUU, (Highlands Hammock State Park) TLEr; Osceola County (Kissimmee) USNM; Pinellas County (Dunedin) PUM; Putnam County (Welaka) CUNY.

4.617 The ovipennis subgroup

This subgroup is characterized by compressed and collapsed median lobe, the orientation of the virga in the median lobe, and the ovate elytra. One species, B. ovipennis LeConte, is included.

4.6171 Brachinus ovipennis LeConte

(Figs. 281, 293, 294, 295, 299, 303)

Brachinus ovipennis LeConte, 1862:525. Lectotype, here selected, a male, MCZ red type label number 31,774, further labelled

with a pink disc, "89" and "B. cephalotes LeC, perplexus Dej, cephalotes LeC, ovipennis LeC." Type locality.—Middle States, as indicated by LeConte's pink disc, but herewith restricted to Vermont.

Brachinus cephalotes LeConte, 1862:525. Lapsus calami.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 7.4 to 10.7 mm.

Color. Metepisterna and sides of abdomen infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and surface of pronotum rugose and punctate, punctures barely impressed.

Head. Frontal furrows moderately impressed. Antennal articles robust, widest about middle. Ligula with sclerotized center area ellipsoid-convex with two lateral rows of three setae per row. Mentum with one to four accessory setae at middle. Submentum with accessory setae.

Prothorax. Pronotum (fig. 281) slightly convex, flattened along center line, sides slightly reflexed. Proepipleura and proepisterna pubescent both anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior surface punctate, punctures in some specimens fused to form weak strigae.

Pterothorax. Elytra elongate, narrow, weakly costate. Humeral angle sloped. Costae and depressions pubescent. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 293, 294, 295). Median lobe with plane of shaft rotated 45° from plane of basal bend. Basal bend short. Apex of shaft narrowly rounded. Dorsal surface of median lobe usually collapsed, ligule ill-defined. Virga (figs. 293, 294), oriented sideways in median lobe. Female (fig. 299). Stylus short, narrow, narrowly rounded at apex.

Variation.—Intrapopulational variation occurs in body size, shape of the pronotum, shape of antennal scape, and amount of area infuscated on venter.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Latin, ovum = egg; pennis = wing; referring to the ovoid-shaped elytra of these beetles.

Collecting notes.—R. T. Bell collected these beetles at the edge of ponds in Vermont, and V. M. Kirk collected them in pitfall traps in cornfields in South Dakota.

Life history.—Members of this species have been collected from March to October. Teneral adults were collected in April in New York, and in September in Indiana, Kansas, and New York. Overwintering probably takes place as an adult.

Distribution.—(Fig. 303). The range of this species extends from New England and Quebec, west to Kansas and South Dakota, south to Texas. I have seen 528 specimens from the following localities:

CANADA

ONTARIO: (Belleville) CNC; (Brimley) ZMLS; (Cedarvale) CAS; (De Cew Falls) CNC; (Erindale) CAS; (Forest Hill Village) CAS; (Point Pelee) ZMLS; (Prince Edward County) CAS, CUNY, MCZ; (Sarnia) UMAH; (Toronto) CAS, CNC, MCZ, ZMLS.

UNITED STATES

CONNECTICUT: Litchfield County (Cornwall) CAS; New Haven County (New Haven) CAS. ILLINOIS: Alexander County (Cairo) ISNH; Cook County (Chicago) CAS, (Evanston) UMAH, (Glencoe) UMAH, (La Grange) CAS, (Riverside) UMAH, (Schiller Park) CNHM; Lake County (Lake Zurich) RTBe, (Waukegan) USNM; Madison County (Mitchell) USNM; Mason County (Havana) ISNH; Rock Island County (Rock Island) UMAH. INDIANA: Knox County (No locality given) PUM; Posey County (Hovey) CEWh, PUM, (Mount Vernon) CEWh. IOWA: Dickenson County (Lake Okoboji) USNM; Johnson County (Iowa City) USNM. KANSAS: Douglas County (Lawrence) PUM, UMAH; Geary County (No locality given) KSU; Hamilton County (No locality given) CAS; McPherson County (McPherson) CMPP; Sedgwick County USNM, (Wichita) CAS; Seward County (No locality given) KSU. MASSACHUSETTS: Hampden County (Chicopee) MCZ, USNM. MICHIGAN: Huron County (Charity Island) UMAH; Kent County (Grand Rapids) UNLN; Macomb County (Mount Clemens) CNHM; Saint Clair County (Port Huron) USNM; Washtenaw County USNM, (Ann Arbor) JSch, UMAH, (Salem) UMAH; Wayne County (Detroit) USNM; County unknown (Pentwater) CNHM. MINNESOTA: Goodhue County (Lake Pepin, east of Frontenac) UMSP, Houston County (No locality given) UMSP; County unknown (Cook Creek) UMSP. MISSOURI: Saint Louis County (Webster Grooves) USNM. NEBRASKA: Douglas County (Omaha) UNLN; Lancaster County (Lincoln) UNLN; Otoe County (Nebraska City) UNLN. NEW YORK: Cayuga County (Montezuma marsh) UASM: Chautauqua County (Dunkirk) CAS; Columbia County (Copake Falls) CNHM; Dutchess County (Red Hook) UMCP; Erie County (Buffalo) ANSP, CAS, CMPP, ISNH, USNM, (Hamburg) CAS; Genesee County (East Bethany) FDAG; Monroe County (Honeoye Falls) CUNY, (Rochester)

LACM, MCZ; New York County (Bronx Park) CAS, (Staten Island) MCZ; Niagara County (Olcott) CUNY; Ontario County (Canandaigua) MCZ; Oswego County (Minetto, Oswego) CUNY; Tompkins County (Groton) UCD, (Ithaca) CAS, CUNY, GRNo, ISNH, KSU, MCZ, OUCO, PSUU, UASM, UCR, UNLN, (Six Mile Creek, Ithaca) TLEr; Schuyler County (Watkins Glen) VMKi; Wyoming County (Gainesville) CUNY; County unknown (Atwaters) USNM, (Danby) UNLN. OHIO: Ashtabula County (Conneaut) PUM, (Rock Creek) PUM, (Saybrook) PUM; Cuyahoga County (Berea) USNM; Hamilton County (Cincinnati) UMAH; Lake County (Perry) PUM; Lucas County (No locality given) PUM; Ottawa County (Gypsum) OUCO; Sandusky County (Winous Point) SJSC. OKLAHOMA: Cleveland County (No locality given) UONO; Comanche County (Wichita National Forest) CAS. PENNSYLVANIA: Allegheny County (Pittsburgh) CMPP; Crawford County (Conneaut Lake) CMPP; Erie County (Fort Erie) CAS; Tioga County (Rutland) ANSP. RHODE ISLAND: Washington County (Watch Hill) USNM. SOUTH DAKOTA: Bennett County (Martin) VMKi; Brookings County (Brookings) SDSU, VMKi, (Volga) VMKi, (White) VMKi; Butte County (Belle Fourche) VMKi; Harding County (Buffalo) VMKi; Hutchinson County (Menno) VMKi; Jones County (Murdo) SDSU; Lawrence County (Spearfish) VMKi; Meade County (Bear Butte) VMKi. TEXAS: Dallas County (Dallas) MCZ. VERMONT: Addison County (Ferrisburg) UMAH; Chittenden County (Burlington) UATA, (Home Creek Delta, Charlotte) RTBe, (Shelburn) CAS, (Shelburn Pond, Shelburn) RTBe; Franklin County (La Moille River, East Georgia) RTBe; Grand Isle County (Alburg) ISNH. WISCONSIN: Dane County (Madison) UWMW; Green County (Brodhead) UMAH; Milwaukee County (No locality given) UWMW.

Figs. 280-283. Pronotum, right half, dorsal aspect. 280. *Brachinus oaxacensis* new species, Rio Atoyac, Oaxaca, Mexico. 281. *Brachinus ovipennis* LeConte, Charlotte, Vermont. 282. *Brachinus patruelis* LeConte, Towaco, New Jersey. 283. *Brachinus conformis* Dejean, Archbold Research Station, Florida. Figs. 284-295. Male genitalia. 284. *Brachinus patruelis* LeConte, Fall River, Massachusetts, ventral aspect. 285. Lateral aspect of same. 286. Dorsal aspect of same. 287. *Brachinus conformis* Dejean, Archbold Research Station, Florida, ventral aspect. 288. Lateral aspect of same. 289. Dorsal aspect of same. 290. *Brachinus oaxacensis* new species, Cacahuamilpa, Guerrero, Mexico, ventral aspect. 291. Lateral aspect of same. 292. Dorsal aspect of same. 293. *Brachinus ovipennis* LeConte, Prince Edward County, Ontario, Canada, ventral aspect. 294. Lateral aspect of same. 295. Dorsal aspect of same. Accompanying scale lines equal 1.0 mm.


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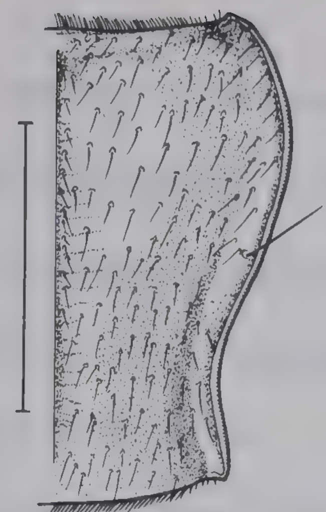
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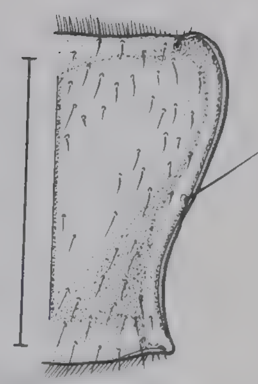
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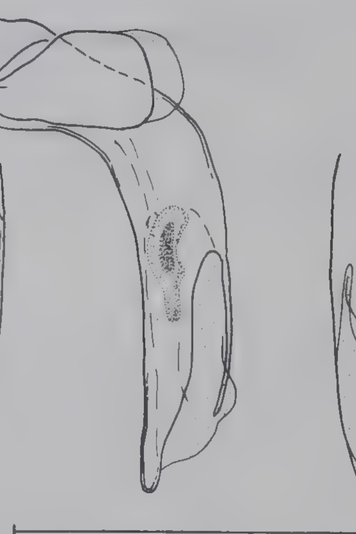
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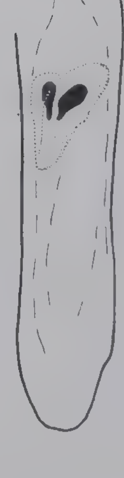
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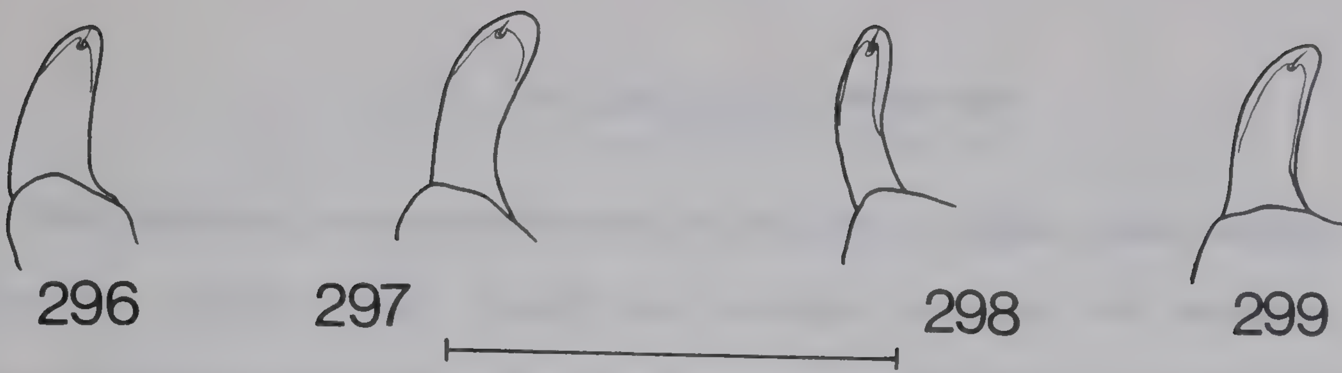
Figs. 296-299. Right stylus of female ovipositor, ventral aspect. 296. Brachinus patruelis LeConte, Fall River, Massachusetts. 297. Brachinus oaxacensis new species, Rio Atoyac, Guerrero, Mexico. 298. Brachinus conformis Dejean, Archbold Research Station, Florida. 299. Brachinus ovipennis LeConte, Ithaca, New York. Figs. 300-303. Geographical distribution maps. 300. Brachinus oaxacensis new species. 301. Brachinus patruelis LeConte. 302. Brachinus conformis Dejean. 303. Brachinus ovipennis LeConte. Accompanying scale line equals 1.0 mm.



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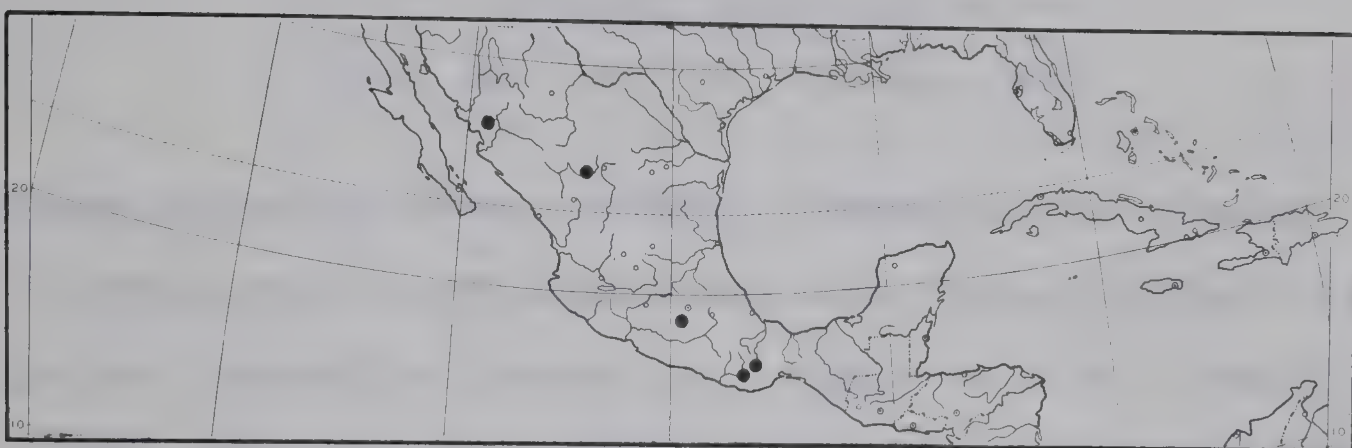

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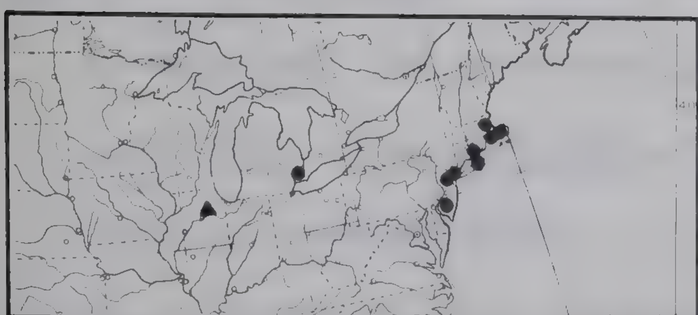

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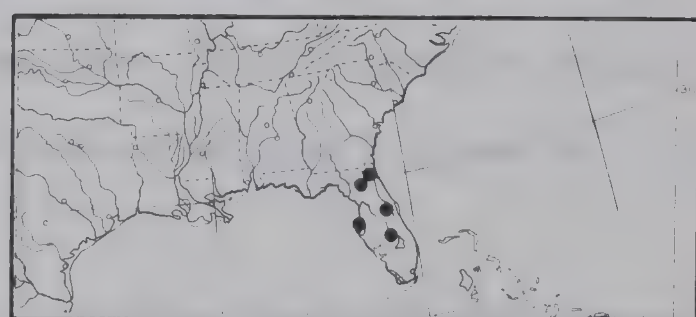

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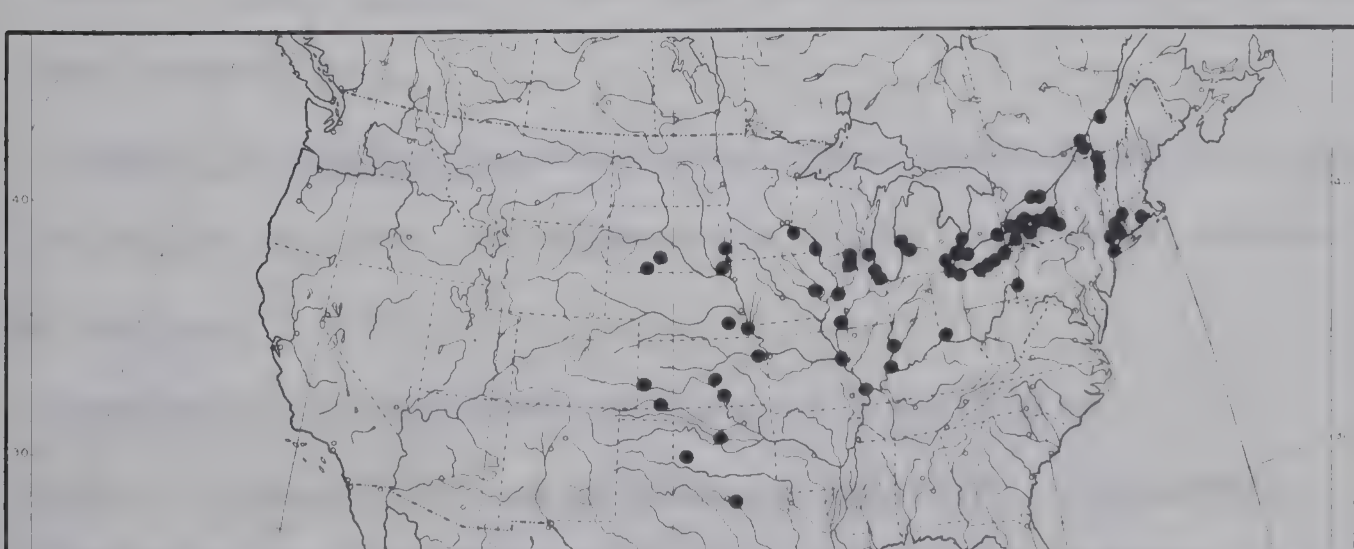

303

4.618 The *tenuicollis* subgroup

This subgroup is characterized as follows: median lobe elongate and narrow, elytra large, square, and strongly costate, and mesepisterna infuscated. One species, *B. tenuicollis* LeConte, is included.

4.6181 *Brachinus tenuicollis* LeConte
(Figs. 307, 312, 313, 314, 324, 329)

Brachinus tenuicollis LeConte, 1844:49. Lectotype, here selected, a female, MCZ red type label number 5849, further labelled with a pink disc and "v. librator Dej., similis LeC., 79 = tenuicollis - cat., similis." *Type locality*.—New York, as originally given by LeConte.

Brachinus ballistarius LeConte, 1848:199. Lectotype, here selected, a male, MCZ red type label number 5846, further labelled with a pink disc. *Type locality*.—New York, as originally given by LeConte. NEW SYNONYMY.

Brachinus similis LeConte, 1848:199. Lectotype, here selected, a female, MCZ red type label number 5849, further labelled as above. *Type locality*.—New York, as originally given by LeConte. NEW SYNONYMY.

Diagnostic combination.—The large size, strongly costate elytra, and infuscated mesepisterna separate these beetles from all others in North America.

Description.—Large-sized beetles, 11.9 to 14.5 mm.

Color. Mesepisterna, mesepimera, metepisterna, metasternum at sides, and abdominal sterna and terga infuscated to black.

Antennal articles 3 and 4 infuscated at apex in some specimens, otherwise beetles ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and disc of pronotum rugose and punctate, punctures barely impressed.

Head. Frontal furrows moderately impressed. Antennal scape cylindrical, or almost so. Ligula with sclerotized center area ellipsoid-convex with two lateral rows of three setae per row. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 307) slightly convex, flattened along center line, sides slightly reflexed. Proepipleura and proepisterna with or without setae. Anterior tibia with anterior surface punctate.

Pterothorax. Elytra elongate, broad, strongly costate. Humeral angle square. Depressions pubescent, costae at least on disc glabrous, smooth. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 312, 313, 314). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend short. Apex of shaft narrow, almost acute. Ligule short, narrow, truncate. Virga (figs. 312, 313). Female (fig. 324). Stylus broad, rounded apically.

Variation.—Intrapopulational variation occurs in the shape of the pronotum and in body size. The proepipleura and proepisterna are glabrous or setose, the setae either spread uniformly over the surface, or restricted anteriorly and posteriorly.

Flight.—These beetles have been collected repeatedly at lights

throughout the range of the species.

Etymology.—Latin, tenuis = thin; collis = neck; referring to the narrow pronotum of these beetles.

Life history.—C. H. Lindroth informs me that H. S. James (Belleville, Ontario) reared at least two specimens of this species from pupal cells of Hydrophilus obtusus Say (Chatterton, Ontario, 2.VIII.56). These beetles have been collected from March to September. It is probable that adults overwinter much the same as in B. pallidus.

Distribution.—(Fig. 329). The range of this species extends from Colorado and western Texas to the east coast from Massachusetts to Maryland and in Florida. The California record is doubtful. I have seen 649 specimens from the following localities:

CANADA

ONTARIO: (Belleville) RTBe; (Chatterton) ZMLS; (De Cew Falls) CNC; (Point Pelee) ROM; (Prince Edward County) CUNY, UATA, UCD; (Toronto) RTBe; (Trenton) CAS, CNC. QUEBEC: (Hull) USNM; (Montreal) CAS; (Outrem't) CAS; (Rigaud) CAS; (Saint Eustache) CAS; (Saint Rose) CAS.

UNITED STATES

ARKANSAS: Benton County (Rogers) KSU; Conway County (No locality given) UAFA; Hempstead County (Hope) MCZ; Lawrence County (Imboden) MCZ; Mississippi County (Osceola) JSch, UMAH; Washington County (No locality given) UAFA. CALIFORNIA: (No locality given) UMSP. COLORADO: Boulder County (Reservoir, Four Mile Mesa) CArm. CONNECTICUT: Hartford County (Windsor) MCZ; New London County (Old Lyme) CAS. FLORIDA: Columbia County (O'Leno State Park) CUNY; Seminole County (Sanford) PUM. ILLINOIS: Cook County (Chicago)

Clemens) CNHM; Midland County (No locality given) JSch; Oakland County (No locality given) OSUS, UMAH; Saginaw County (No locality given) UMAH; Van Buren County (Paw Paw Lake) UMAH; Washtenaw County OSUS, (Ann Arbor) UMAH, (Whitmore Lake) CCha, JSch; Wayne County (Rockwood) UMAH; Wayne County (Detroit) MCZ, UMAH, USNM, (Eight Mile Road) UMAH; Counties unknown (Aurelius) OSUS, (Dun Scotus) PSUU, MINNESOTA: Dakota County (No locality given) UMSP; Hennepin County (No locality given) UMSP; Houston County (3.0 miles north of Hokah) UMSP; LeSeuer County (Lake Madison) UMSP; Nicollet County (Saint Peter) UMSP; Pine County (mouth of Snake River) UMSP, (4.0 miles east of Pine City) USNM; Ramsey County (Saint Paul) ISNH; Washington County (Saint Croix River) UMSP; Watonwan County (No locality given) UMSP. MISSISSIPPI: George County (Lucedale) CUNY. MISSOURI: Carter County (Van Buren) UMAH; Vernon County (Nevada Area) TLEr. NEBRASKA: Lancaster County (Lincoln) UNLN; Nemaha County (Peru) UNLN. NEW JERSEY: Essex County (Cedar Grove) USNM; Morris County (Boonton) USNM, (Lincoln Park) CAS, CNHM, (Towaco) USNM. NEW MEXICO: San Miguel County (Las Vegas) CMPP. NEW YORK: Cayuga County (Montezuma Marsh) UASM; Erie County (Buffalo) ISNH, MCZ; Genesee County (Batavia) CUNY; Monroe County (Rochester) LACM, MCZ; New York County (Cypress Hills) AMNH; Niagara County (Olcott) CUNY; Ontario County (Canandaigua) MCZ; Oswego County (Oswego) ANSP, CUNY; Saint Lawrence County (Rossie) JSch; Tompkins County (Ithaca) CAS, CUNY, MCZ; County unknown (Meadowdale) CUNY. OHIO: Ashtabula County (Rock Creek) PUM. OKLAHOMA: (No locality given) CCha. TENNESSEE: Lake County (Gray's Lodge) RTBe. TEXAS: Brazos County (College Station) TAMU; Brewster County (Alpine) MCZ; Dallas County

(Dallas) MCZ; Hudspeth County (9.0 miles southwest of Del City) AMNH; San Patricio County (Welder Wildlife Refuge, near Sinton) CNC; Victoria County (Victoria) USNM; County unknown (Fuller) USNM. VERMONT: Chittenden County (Burlington) RTBe, (Shelburne Pond, Shelburne) RTBe. WISCONSIN: Calumet County (No locality given) PUM; Crawford County (Wauzeka) UWMW; Dane County (No locality given) UWMW; Wood County (Griffith Street Nursery) UWMW, (Port Edwards) UWMW.

4.619 The *cyanipennis* subgroup

This subgroup is characterized by: median lobe with broad ligule, pronotum strongly cordate, and erect depression setae two to three times as long as the elytral pubescence. One species, *B. cyanipennis* Say, is included.

4.6191 *Brachinus cyanipennis* Say

(Figs. 304, 308, 309, 310, 326, 330)

Brachinus cyanipennis Say, 1823:143. Neotype designated by Lindroth (MS), a male, in MCZ. The specimen was selected by me, from University of Iowa material, and sent to Lindroth. He subsequently deposited all Say's neotypes in MCZ. *Type locality*.—Ames, Iowa. This locality is the nearest to Say's original area from which we had specimens. The original area was "fissures of the rocks...near Engineer Cantonment" near Council Bluffs, Iowa.

Brachinus cephalotes Dejean, 1825:317. Lectotype, here selected, a male, MHNP, labelled "cephalotes m. h. in Amer. bor."

"Latreille" and "Ex Museo Chaudoir" and standing first, in first of two rows below box label "cyanipennis Say." Type locality.—"Amerique septentrionale" as originally given by Dejean. NEW SYNONYMY.

Brachinus cordicollis LeConte, 1862:525. Lapsus calami.

Brachinus rejectus LeConte, 1862:525. Lectotype, here selected, a female, MCZ red type number 5843, further labelled with a pink disc and "B. cordicollis LeC. cyanipennis Say, cordicollis LeC., rejectus LeC." Type locality.—Kansas, as originally given by LeConte. NEW SYNONYMY.

Diagnostic combination.—The erect depression setae of the elytra standing two to three times higher than the elytral pubescence separates these beetles from all others in the United States.

Description.—Medium-sized beetles, 8.0 to 12.0 mm.

Color. Metepisterna usually infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and surface of pronotum rugose and punctate, punctures moderately impressed.

Head. Frontal furrows moderately impressed. Antennal scape robust, widened apically. Ligula with sclerotized center area ellipsoid-convex with two lateral rows of three setae per row. Mentum of some specimens with one or two small setae at center; submentum without accessory setae.

Prothorax. Pronotum (fig. 304) convex, strongly cordiform, sides moderately reflexed. Proepipleura and proepisterna with a few scattered setae both anteriorly and posteriorly, glabrous medially.

Anterior tibia with anterior surface strigose.

Pterothorax. Elytra moderately long, narrow, moderately costate. Humeral angle square. Costae smooth on disc, otherwise pubescent, depressions pubescent. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 308, 309, 310). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend long. Apex of shaft blunt. Ligule short, widened apically, truncate. Virga (figs. 308, 309). Female (fig. 326). Stylus long, narrow, almost acute apically.

Variation.—Intrapopulational variation occurs in the following characteristics: the center of the mentum bears or lacks a few accessory setae; the antennal articles 3 and 4, metepisterna, and sides of the abdomen are or are not infuscated; the apex of the shaft is or is not notched; and the virga is narrowly or broadly rounded apically.

Flight.—These beetles have been recorded at lights in South Dakota.

Etymology.—Greek, kyanos = blue; Latin, pennis = wing; referring to the blue elytra of these beetles.

Collecting notes.—C. Chantal collected these beetles on river terraces above the Becancour River in Quebec. The beetles were beneath stones on sandy clay.

Life history.—Members of this species have been collected from March to October. Teneral adults were collected in May in Kansas. Overwintering probably takes place as an adult.

Distribution.—(Fig. 330). The range of this species extends

from New Brunswick through New England, west to New Mexico, and south to Texas and Alabama. I have seen 2,095 specimens from the following localities:

CANADA

MANITOBA: (Lake Jessica, northeast of Winnipeg) UASM. NEW BRUNSWICK: (Saint John) USNM. ONTARIO: (Belleville) ZMLS; (Go Home Bay) CNC; (Kenora) ZMLS; (2.0 miles north of Little Current) UASM; (Marmora) CNC; (Oliphant, Bruce Penisula Lake Huron) ZMLS; (Otter Lake, 9.0 miles south of Smith Falls) CCh; (Presque Isle) UASM; (Sever) CMPP; (Toronto) CAS, RTBe; (Walsingham, southwest of Simcoe) ZMLS. QUEBEC: (Becancour) CCh, OSUC; (Como) CNC, CUNY, MCZ; (Montreal) MCZ; (Outrem't) CAS; (Rigaud) CAS, CCh; (Saint Ours) CCh; (Terreb'ne) CAS.

UNITED STATES

ALABAMA: Baldwin County (No locality given) UASM; Mobile County (Calvert) ANSP, UASM, (Mobile) CAS. ARKANSAS: Pulaski County (Little Rock) AMNH. CONNECTICUT: Fairfield County (Canbury) AMNH; Hartford County (Burlington) ISUA; Litchfield County AMNH, (Cornwall) CAS, CUNY; New Haven County (Hamden) CAS, (New Haven) CAS, (South Meriden) CAS, MCZ; Tolland County (Union) ISUA; County unknown (Yoshen) AMNH. DELAWARE: County unknown (Watergap) AMNH. DISTRICT OF COLUMBIA: (Black Pond) USNM, (Rock Creek, Washington) USNM. ILLINOIS: Champaign County (Urbana) UMPP; Hancock County (Hamilton) ISUA: Knox County (Galesburg) MCZ; La Salle County (No locality given) RTBe; McHenry County (McHenry) WSUP; Vermilion County (Camp Robert Drake, Fairmount) RTBe. INDIANA: Fulton County (No locality given) PUM; Kosciusko County (Winona Lake) UMAH; Knox County (No

locality given) PUM; Lake County (Miller) UMAH; Montgomery County (Shades) PUM, RTBe. IOWA: Boone County (Ledges State Park) ISUA; Clayton County (Guttenberg) ISUA, USNM; Dickinson County (Spirit Lake) USNM, UWMW; Johnson County (Iowa City) MCZ, USNM; Lee County (Fort Madison) ANSP, CMPP, MCZ, ZMLS; Palo Alto County (Ruthven) ISUA; Story County (Ames) ISUA; County unknown (Herrold) CAS. KANSAS: Douglas County (Lawrence) ANSP, CMPP, UWNW, (Lone Star) CNC; Reno County (Medora) MCZ; Riley County (Marlatt) KSU. KENTUCKY: Fayette County (Lexington) TCBa; Rowan County (Morehead) CNC. MAINE: Cumberland County (Sebago Lake, South Casco) AMNH; Oxford County (Norway) MCZ, (Paris) CUNY; Penobscot County (Orono) UATA, UMSP. MARYLAND: Baltimore County (Baltimore) CAS, MSUM; Montgomery County (No locality given) USNM; County unknown (Plummers Islands) USNM. MASSACHUSETTS: Barnstable County (Barnstable) MCZ, (Hyannis) ISUA, (Woods Hole) WSUP; Bristol County (Attleboro) ZMLS, (Fall River) CAS, (Swansea) MCZ; Franklin County (Northfield) MCZ; Hampden County (Chicopee) MCZ; Hampshire County (Amherst) CEWh, MCZ, (Mount Tom) CMPP, USNM; Middlesex County (Arlington) CAS, UASM, (Billerica) CAS, UASM, ZMLS, (Concord) MCZ, UASM, ZMLS, (Lincoln) MCZ, (Pepperell) UATA, (Sherborn) MCZ, (Sudbury) MCZ, (Tyngsboro) MCZ, (Wayland) MCZ, (Waltham) MCZ, (Woburn) MCZ; Nantucket County (Nantucket) ISNH, MCZ; Norfolk County (Brookline) MCZ, (Dedham) MCZ, (Dorchester) MCZ, (Dover) MCZ, (Sharon) CUNY, (Stoughton) USNM, (Wellesley) MCZ, (Westwood) MCZ; Worcester County (Ashburnham) CEWh; County unknown (Mount Toby) MCZ. MICHIGAN: Allegan County (Allegan) CAS; Charlevoix County (Beaver Island) UMAH; Eaton County (Grand Ledge) USNM; Grand Traverse County (Marion Island) UMAH; Huron County (San Point) UMAH;

Kalamazoo County OUCO, (Gull Lake Biology Station) JSch; Kent County (Grand Rapids) UNLN; Lake County (Loon Lake) UMAH; Oakland County (No locality given) UMAH; Oceana County (Crystal Valley) CNHM; Otsego County (Lake Manuka) UMAH; Ottawa County (No locality given) KSU, PUM; Washtenaw County (Ann Arbor) UMAH, (Whitmore Lake) JSch. MINNESOTA: Benton County (No locality given) UMSP; Big Stone County (No locality given) UMSP; Clearwater County (Itasca State Park) UMSP; (Itasca State Park, Bohall Lake) UMSP, (Itasca State Park, De Soto Lake) UMSP; Crow Wing County (Mille Lacs Lake, near Garrison) UMSP; Dakota County (No locality given) UMSP; Douglas County (Alexandria) PSUU, UMSP; Hennepin County (Minneapolis) UMSP; Houston County (Mississippi Bluff, 1-2.0 miles north of State Line) UMSP; Lac qui Parle County (Madison) UMSP; Lake County (Basswood Lake) UMSP; Norman County (No locality given) UMSP; Otter Tail County (Battle Lake) UMSP; Pine County (Saint Croix River, 10.0 miles east of Pine City) UMSP, (Snake River, 6.0 miles east of Pine City) UMSP; Ramsey County UMSP, (Saint Paul) ISNH, WSUP; Traverse County (No locality given) UMSP; Washington County (Saint Croix River, 3.0 miles north of Stillwater) UMSP; County unknown (Cliff) UMSP. MISSISSIPPI: George County (Lucedale) CUNY. MISSOURI: Jefferson County (Kimmswick) USNM; Saint Louis County (No locality given) LACM. NEBRASKA: Dakota County (Hubbard) UNLN, (South Sioux City) UNLN; Lancaster County (Lincoln) UNLN; Saunders County (Cedar Bluffs) UNLN. NEW HAMPSHIRE: Cheshire County (Swanzey Pond) MCZ; County unknown (Three Mile Island) MCZ. NEW JERSEY: Bergen County (Bear Swamp, Ramsey) AMNH, (Emerson) CAS, (Oakland) CAS; Cumberland County (Bridgeton) CAS; Essex County (Cedar Grove) USNM; Hunterdon County

(Hampton) AMNH; Morris County (Riverdale) MCZ; Passaic County (Great Notch) USNM; Somerset County (North Branch) DRWh; Union County (Berkeley Heights) AMNH; Warren County (Phillipsburg) CAS; County unknown (Chelcea) CMPP, (Split Rock Lake) CAS, USNM. NEW MEXICO: (No locality given) CMPP. NEW YORK: Clinton County (Plattsburg) CAS; Columbia County (Hudson) CAS; Cortland County (McLean Bogs) CUNY; Dutchess County (Red Hook) UMCP; Essex County (Fort Ticonderoga) PUM; New York County (Broad Channel) CAS, (Bronx Park) CAS, (Brooklyn) LACM, USNM, (New York City) CAS, MCZ, (Rockaway Beach) MCZ, (Staten Island) CAS, USNM, (Yonkers) CAS, CNHM, MCZ; Niagara County (Olcott) CUNY; Orange County (West Point) UMAH, USNM; Otsego County (Unadilla) MCZ; Putnam County (2.0 miles northwest of Brewster) PUM; Queens County (Cunningham Park) CAS; Rockland County (Bear Mountains) CNHM; Saint Lawrence County (Canton) OSUS; Suffolk County (Babylon) AMNH, (Montauk) CNHM, MCZ, (Southold) CUNY, (Wildwood State Park) CUNY; Tompkins County (Ithaca) CAS, CUNY, UASM, UIMI, (McLean) UMSP, (Tomkins Cove) AMNH, (Varna) UASM; Ulster County (Ashokan) AMNH, (Phoenicia) CAS; Washington County (Salem) CAS; Westchester County (Bedford) CAS, (Peekskill) MCZ; Wyoming County (Silver Lake) CAS; Counties unknown (Catskill Mountains) AMNH, (Hebron) AMNH, USNM, (Miller's Port) CUNY. OHIO: Coshocton County (Mohican River) PUM. OKLAHOMA: Cleveland County (No locality given) OUCO; Payne County (Stillwater) OSUS. PENNSYLVANIA: Allegheny County (Pittsburgh) CAS; Bradford County (Susquehanna River, Wyalusing) CAS, UASM; Burks County (No locality given) MCZ; Chester County (West Chester) UWMW; Cumberland County (New Cumberland) UASM, VMKi; Dauphin County (Harrisburg) CUNY, VMKi; Franklin County (Chambersburg) USNM; Monroe

County (No locality given) USNM; Montgomery County (Arcola) OUCO; Northampton County (Easton) CAS, UASM, (Water Gap) AMNH; Pike County (Camp Colang) CNHM; Philadelphia County (Chestnut Hill) USNM; Venango County (French Lick Creek, south of Venango) PUM; Counties unknown (Belfast) CAS, (Bethlehem) CNHM, (Edge Hill) USNM, (Lehigh Water Gap) USNM, (North Cumberland) CAS. RHODE ISLAND: Kent County (Quonset Point) CAS; Newport County (Newport) CNHM; Providence County (Providence) CMPP; County unknown (Moswansicut Lake) CMPP. SOUTH DAKOTA: Brookings County (Brookings) CMPP, SDSU, (Volga) VMKi; Hyde County (Highmore) SDSU. TENNESSEE: Lake County (No locality given) RTBe. TEXAS: Coryell County (No locality given) MCZ; Frio County (5.0 miles north of Dilley) UASM; Kerr County (Kerrville) CNC; McLennan County (Waco) MCZ; Travis County (Austin) WSUP. VERMONT: Addison County (Lewis Creek, North Ferrisberg) RTBe; Chittenden County (Burlington) RTBe, (Gilette Pond, Richmond) RTBe, (La Moille River, Milton) RTBe, (Sandbar State Park) RTBe, (Shelburne) CAS; Franklin County (La Moille River, East Georgia) RTBe; Grand Isle County (Alburg) RTBe; Lamoille County (Ithiel Falls, Johnson) RTBe; Orange County (Wells River) MCZ; Windham County (Brattleboro) USNM, (West River, Newfane) RTBe, (West River, Townshend) RTBe; Counties unknown (Lake Champlain, West Haven) RTBe, (West River, Brookline) RTBe. VIRGINIA: Fairfax County (Great Falls) ISUA, USNM; Loudoun County ANSP, (Harpers Ferry) USNM. WISCONSIN: Bayfield County (Lake Namekagon) UWMU; Dane County (No locality given) UWMW; Dodge County (Beaver Dam) UMAH; Milwaukee County (No locality given) CAS; Portage County (Stevens Point) SWMW; Sauk County (Praire du Sac) CNHM; (Victory) USNM.

4.620 The *medius* subgroup

This subgroup is characterized as follows: size small, venter infuscated, female stylus small, arcuate, and median lobe small, generalized. One species, *B. medius* Harris, is included.

4.6201 *Brachinus medius* Harris

(Figs. 311, 315, 316, 317, 328, 331)

Brachinus medius Harris, 1828:117. Lectotype, here selected, a male MCZ red type label number 26411. *Type locality*.—Boston, Massachusetts. Here designated, because Harris neither labelled his specimens, nor gave a locality in his descriptions, but he collected in the Boston area.

Brachinus minutus Harris, 1828:117. Lectotype, here selected, a male, MCZ red type label number 26412, further labelled "471 female, 104." Harris misidentified the sex of the beetle. *Type locality*.—Boston, Massachusetts (see above). NEW SYNONYMY.

Diagnostic combination.—The small size, glabrous proepisterna, and infuscated abdomen separate these beetles from all others in the study area.

Description.—Small-sized beetles, 5.2 to 7.3 mm.

Color. Antennal articles 3-11, metepisterna, and abdominal sterna and terga infuscated. Antennal articles 1 and 2, metepisternum at sides, apex of tibia, and tarsi infuscated in some specimens, in others these sclerites are ferrugineous. Dorsal surface and epipleura of elytra blue, with greenish luster in some specimens.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and surface of pronotum rugose and punctate, punctures barely impressed.

Head. Frontal furrows moderately impressed. Antennal scape robust, widened apically. Ligule with sclerotized center area ellipsoid-convex with two lateral rows of three setae per row. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 311) slightly convex, flattened along center line, sides slightly reflexed. Proepipleura, and usually proepisterna glabrous, the latter sometimes with 1-3 setae near anterior edge. Anterior tibia with anterior surface strigose.

Pterothorax. Elytra short, narrow, slightly costate. Humeral angle square. Depressions and costae pubescent. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 315, 316, 317). Median lobe with plane of shaft rotated 45° from plane of basal bend. Basal bend long. Apex of shaft blunt, slightly turned dorsally. Ligule short, narrowed toward apex. Virga (figs. 315, 316). Female (fig. 328). Stylus small, short, narrow, slightly arcuate, narrowly rounded apically.

Variation.—Intrapopulational variation occurs in the following characteristics: shape of pronotum; body size; proepipleura with or without setae; and color as indicated above. The elytra are greenish only in the Brownsville, Texas area.

Flight.—These beetles have been collected at lights in South Dakota, Minnesota, and Texas.

Etymology.—Latin, medius = middle. Harris described this species in 1828, using two names because he had two very small specimens

and two medium-sized specimens, in comparison with other New England Brachinus species. He called the small ones minutus and the others medius.

Collecting notes.—D. R. Whitehead collected these beetles from under stones along an intermittent stream in Texas. G. E. Ball collected them on the shores of a Texas lake. Other records indicate they also inhabit bogs, edges of reservoirs, and marshes.

Life history.—Members of this species have been collected in all months, except December. Teneral adults were collected in September in Michigan. Overwintering probably takes place as an adult.

Distribution.—(Fig. 331). The range of this species is disjunct. The general pattern is much the same as in B. quadripennis. I have seen 979 specimens from the following localities:

CANADA

BRITISH COLUMBIA: (Atbara, near Creston) UASM, ZMLS; (Osoyoos) CAS, ISNH, ISUA, ZMLS; (Salmon Arm) CNHM, CUNY, MCZ, UATA; (Shuswap Lake) ZMLS. ONTARIO: (Belleville) CNC; (Britannia) CNC; (Constance Bay) CNC; (Hamilton) CNHM; (Osgoode) CNC; (Toronto) CAS; (Trenton) MCZ. QUEBEC: (Becancour) CCha; (Choisypr Rigaud) ZMLS; (Fort Coulonge) CAS, CNC; (Montreal) CAS; (Rigaud) CAS; (Saint Eustache) CAS; (Saint Ours) CCha; (Saint Rose) CAS.

MEXICO

TAMAULIPAS: (9.9 miles west of Pesca) UASM.

UNITED STATES

ALABAMA: Mobile County (Mobile) APSP, CAS, UMAH, USNM, (Orchard) CAS, KSU, (Spring Hill) USNM. CALIFORNIA: ANSP, UMSP, USNM, UWMW,

San Diego County (San Diego) MCZ. COLORADO: Boulder County (Boulder Creek) CArm, (Crystal Lake) CArm, (Erie) CArm, (Longmont, Bellmire Reservoir) CArm, (Longmont, Divide Reservoir) CArm, (Rod and Gun Club Lake) CArm, (Teller Lake) CArm, (Viele Lake) CArm; Weld County (Greeley) USNM. CONNECTICUT: (No locality given) USNM. FLORIDA: Alachua County (Gainesville) FDAG, (4.0 miles north of High Springs) CNC, (Newnans Lake, 5.0 miles east of Gainesville) RFre; Duval County (Jacksonville) CAS, OUCO; Highlands County (Archbold Biology Station) PSUU; Hillsborough County (Tampa) USNM; Manatee County (Oneco) UASM; Marion County (3.0 miles southwest of Lake Marion) CNC; Osceola County (No locality given) FDAG; Pinellas County (Dunedin) PUM, UMAH; Sarasota County (Myakka River State Park) CUNY, UASM. GEORGIA: Baker County (Newton) CNC; Charlton County (Okefenokee Swamp) TLEr. KANSAS: Sheridan County (State Lake, near Studley) RFre, UASM. IDAHO: Bonner County (Sagle) UWSW; County unknown (Sand Point) UWSW. ILLINOIS: Cook County (Chicago) UWSP; McHenry County (Algonquin) ISNH; Rock Island County (Moline) UMSP. INDIANA: Vigo County (No locality given) PUM. IOWA: Buchanan County (Independence) MCZ, USNM; Clayton County (Guttenberg) USNM; Des Moines County (Burlington) ANSP; Dickenson County (Lake Okoboji) USNM, (Spirit Lake) UWMW; Johnson County (Iowa City) MCZ, USNM; Lee County (Fort Madison) CAS, (Keokuk) USNM; Story County (Ames) ISUA. MARYLAND: (No locality given) UMSP. MASSACHUSETTS: Bristol County (Fall River) ISUA, MCZ; Hampshire County (Mount Tom) CMPP, USNM; Middlesex County (Acton) CNC, (Arlington) CNC, MCZ, (Billerica) CNC, CUNY, (Boston) CAS, USNM, (Cambridge) ANSP, (Concord) MCZ, (Sudbury) CEWh, MCZ, (Waltham) MCZ, (Wayland) CNC, CNHM, MCZ, UASM; Norfolk County (Newton) MCZ, (Sharon)

CUNY; Plymouth County (Marion) MCZ; Suffolk County (Dorchester) MCZ; Worchester County (Fitchburg) USNM; County unknown (Forest Hills) USNM. MICHIGAN: Alcona County UMSP; Charlevoix County (Beaver Island) UMAH; Cheboygan County (No locality given) CUNY; Huron County (Charity Island) UMAH; Kalamazoo County (Gull Lake Biology Station) TFHl; Lapeer County UMAH, (Lapeer State Game Area) RCGr; Livingston County (E. S. George Reserve) UMAH; Menominee County (Menominee) CEWh; Oakland County (No locality given) UMAH; Wayne County (Detroit) MCZ, UMAH; Washtenaw County (Ann Arbor) UMAH. MINNESOTA: Crow Wing County (Nisswa) UMSP; Hennepin County (Bloomington) ISNH; Olmsted County (No locality given) UMSP; Polk County (Crookston) UMSP; Ramsey County (Saint Paul) UMSP. MISSOURI: (No locality given) ANSP, USNM. MONTANA: Sanders County (Perma) LRus. NEBRASKA: (No locality given) ANSP. NEW HAMPSHIRE: Strafford County (Milton) MCZ. NEW JERSEY: Bergen County (Emerson) CAS; Cape May County (Cape May) CAS; Morris County (Boonton) USNM. NEW YORK: Cortland County (McLean Bogs) CAS, CUNY; Erie County (Buffalo) AMNH, ANSP; Essex County (Fort Ticonderoga) PUM; Monroe County (Rochester) LACM; Nassau County (Hewlett) USNM, (Roslyn) CAS; New York County (New York City) MCZ, (Yonkers) CAS, MCZ; Niagara County (Olcott) CUNY; Orange County (West Point) USNM; Queens County (Queens) CAS; Suffolk County (Brookhaven) UASM, VMKi, (Montauk Point) CNHM, CUNY, (Riverhead) VMKi; Tompkins County (Ithaca) CAS; Westchester County (Bedford) CAS, (Mount Vernon) CNHM; County unknown (Chicago Bog) UMSP. NORTH DAKOTA: Benson County (11.9 miles west of York) UASM; Grand Forks County (University) USNM. OKLAHOMA: Marshall County (Lake Texoma, Willis) RCGr. OHIO: Adams County (No locality given) OUCO; Cuyahoga County

(Cleveland) MCZ; Lawrence County (Miller) UMAH; Tuscarawas County (No locality given) OUCO. OREGON: Clackamas County (Oregon City) CAS; Multnomah County (Portland) CAS, USNM; County unknown (Sauvie Island) JSch. PENNSYLVANIA: Lackawanna County (Scranton) UASM, USN; Westmoreland County (Jeannette) CMPP. SOUTH CAROLINA: Florence County (Florence) VMKi; Sumter County (Poinsett State Park) VMKi. SOUTH DAKOTA: Beadle County (Huron) VMKi; Brookings County (Brookings) SDSU, VMKi; Brown County (Hecla) SDSU; Clay County (Vermillion) SDSU; Lawrence County (Spearfish) VMKi; Yankton County (Yankton) VMKi. TEXAS: Blanco County (Cypress Mill) USNM; Cameron County (Brownsville) CAS, CNC, OUCO, SJSC, TLEr, USNM; Hidalgo County (Hidalgo) CMPP, (McAllen) UMAH, (Weslaco) TAMU; Reeves County (Balmorhea Lake) UASM, (Pecos) CNC; Sutton County (Sonora) TAMU; Terrell County (Chandler Ranch) UASM, (16.0 miles north of Dryden) UASM, (Lozier Canyon) MCZ; Val Verde County (9.0 miles southeast of Del Rio) DRWh; Victoria County (Victoria) USNM. UTAH: Salt Lake County (Salt Lake City) USNM; Utah County (Provo) MCZ, USNM. VERMONT: Addison County (Dead Creek, Addison) RTBe, (Lewis Creek, North Ferrisberg) RTBe; Chittenden County (Shelburne) CAS. WASHINGTON: Adams County (Ritzville) CAS, PUM, USNM, UWSW; Lincoln County (Sprague Lake) CAS; County unknown (Yakima River, Morgan's Ferry) MCZ. WISCONSIN: Bayfield County (No locality given) UWMW; Dane County (No locality given) ANSP; Wood County (Griffith Street Nursery) UWMW.

4.621 The *gebhardis* subgroup

This subgroup is characterized by elytra with pubescence restricted to depression 8, and by the form of the median lobe.

(Pecos) CNu; Sutton County (Sonora) TAMU; Terr

The two species, _B_. _gebhardis_ Erwin, and _B_. _galactoderus_ new species, included here are very similar in their external form.

4.6211 _Brachinus_ _gebhardis_ Erwin

(Figs. 306, 321, 322, 323, 327, 332)

Brachinus _gebhardis_ Erwin, 1965:6. Holotype male and allotype female are in CAS. _Type_ _locality_.—Uvas Creek, 5.0 miles west of Morgan Hill, Santa Clara County, California.

Diagnostic _combination_.—The presence of pubescence in the eighth depression only, the pale center of the venter, and the accessory setae of the mentum separate these beetles from all others in North and Middle America.

Description.—Medium-sized beetles, 7.0 to 12.0 mm.

Color. Metepisterna and sides of abdomen infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and surface of pronotum rugose and punctate, punctures moderately impressed.

Head. Frontal furrows moderately impressed. Antennal scape cylindrical. Ligula with sclerotized center area ellipsoid-convex with two lateral rows of three setae per row. Mentum and submentum with accessory setae.

Prothorax. Pronotum (fig. 306) slightly convex, flattened along center line, sides narrowly reflexed. Proepipleura and proepisterna with scattered setae both anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior surface strigose.

Pterothorax. Elytra elongate, narrow, moderately costate.

Humeral angle square. Depression 8 pubescent. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 321, 322, 323). Median lobe with plane of shaft moderately rotated from plane of basal bend. Basal bend short. Apex of shaft narrowed, almost acute. Ligule moderately long, broad, and rounded apically. Virga (figs. 321, 322). Female (fig. 327). Stylus narrow, arcuate, almost acute apically.

Variation.—Intrapopulational variation occurs in the following characteristics: width of the pronotal explanation at the anterior angles; presence or absence of the accessory setae on the mentum; sides of abdominal sterna infuscated or not; occasionally the metasternum is infuscated at sides. On the whole, the Arizona populations have larger members without mental accessory setae, but with wider pronotal explanations, and wider shafts of the median lobe.

Flight.—These beetles have been collected at lights by G. E. Ball in Arizona.

Etymology.—Greek, geb = born; Old French, hardi = shovel-shaped; referring to the "spade-shaped" dorsal outline of these beetles.

Collecting notes.—In Santa Clara County, California, these beetles occur along the margins of intermittent streams. The sides of the streams are generally rocky with underlying gravel, and very little vegetation near the actual stream, although emergent specimens of *Salix* species (at high water) are found in some areas.

Life history.—Members of this species have been collected in all months, except December. Teneral adults were collected in September in Santa Clara County, California. Overwintering probably takes place in the adult stage.

Distribution.—(Fig. 332). The range of this species extends from northern California, to the San Jacinto Mountains of southern California. Other aggregates of populations occur in southern Arizona, and in southern Baja California. I have seen 151 specimens from the following localties:

MEXICO

BAJA CALIFORNIA: (1.3 miles northwest of El Triunfo) CAS.

UNITED STATES

ARIZONA: Graham County (10.0 miles southwest of Safford) UCR; Santa Cruz County (Madera Canyon) UCD, CUNY, (Peña Blanca) UASM, (Yanks Spring, 4.0 miles southeast of Ruby) AMNH; Pima County (Box Canyon, Santa Rita Mountains) CNHM, (west side of Baboquivari Mountains) CAS, (Browns Canyon, Baboquivari Mountains) AMNH, (Santa Catalina Mountains) CAS, (Santa Catalina Mountains, Sabino Canyon) CAS, TCBa, UASM, (Santa Rita Mountains) CAS, (Tanque Verde) UATA, (Tucson) CAS. CALIFORNIA: Alameda County (Alameda Creek) CAS, (Arroyo Mocho) TLEr, (Berkeley) USUL; Amador County (Horse Creek) TLEr; Fresno County (Le Fevre) ANSP; Los Angeles County (2.7 miles south of Little Rock Ranger Station) GRNo, (Pasadena) CAS, MCZ, (San Francisquito Canyon) LACM, (San Gabriel Canyon) CAS, TCBa, (Soledad Canyon) LACM, (Tanbark Flat) UCR; Monterey County (Bryson) CAS; Orange County (Lower San Juan Campground) LACM; Riverside County (San Jacinto Mountains) CAS; San Diego County (Valley Center) SDNHM; San Luis Obispo County (Atascadero) CAS, (San Luis Obispo) CAS; Santa Barbara County (Buellton) CAS, (Cuyama River) CAS, (4.0 miles east of Los Prietos) UCD, (Oso Canyon) UCD, (Santa Barbara) MCZ, (Santa Cruz Island) CAS, (West Santa Ynez River) UCD; Santa Clara County CNHM, (Gilroy Hot

Springs) TLEr, (Mount Hamilton) JSch, (Pacheco Pass) UIMI, (Uvas Creek) TLEr; Stanislaus County (Del Puerto Creek) TLEr, (20.0 miles west of Patterson) TLEr; Ventura County (Foster Park) UCD, (Ojai) MCZ, (Santa Clara River, Santa Paula) CUNY, County unknown (Cachuma Reservoir) CAS, (Shephards Inn) MCZ.

4.6212 Brachinus galactoderus new species

(Figs. 305, 318, 319, 320, 325, 333)

Type locality.—Rio Papagayo, 41.4 miles north of Acapulco, Route 95, 700 feet, Guerrero, Mexico.

Type specimens.—The holotype male and allotype female are in MCZ. Both were collected at the type locality by G. E. Ball and D. R. Whitehead on December 20, 1965. Four paratypes collected at various localities and on various dates are in CAS, MCZ, TLEr, and UASM.

Diagnostic combination.—The milky appearance of the surface of the pronotum will separate these beetles from all others in Mexico.

Description.—Medium-sized beetles, 9.3 to 10.6 mm.

Color. Metepisterna, metasternum at sides, abdominal sterna and terga infuscated, otherwise ferrugineous. Dorsal surfaces and epipleura of elytra slate-black without blue luster.

Microsculpture. As described for genus, except surface of pronotum with isodiametric meshes raised into beads which apparently scatter the reflected light producing a milky appearance.

Macrosculpture. As in gebhardis.

Head. Frontal furrows moderately impressed. Antennal scape robust, widest about middle. Ligula with sclerotized center area ellipsoid-convex with two apical setae. Mentum and submentum without

accessory setae.

Prothorax. As in gebhardis, except proepipleura glabrous.

Pterothorax. As in gebhardis.

Abdomen. As described for genus.

Genitalia. Male (figs. 318, 319, 320). Median lobe with plane of shaft rotated about 30° from plane of basal bend. Basal bend short. Apex of shaft narrowed, almost acute. Ligule long, broad, tapering to narrow apex. Virga (figs. 318, 319). Female (fig. 325). Stylus short, broad, tapering to narrowly rounded apex.

Variation.—Intrapopulational variation occurs in the shape of the pronotum, and in total size. A cline may occur in the color of the knees. Those populations in the north have darkened knees, while those in Oaxaca and Guerrero have pale knees. No specimens are available from Jalisco and Michoacan to see where this trend develops.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Greek, galaktos = milky; derus = neck; referring to the milky appearance of the pronotum of these beetles.

Collecting notes.—G. E. Ball and D. R. Whitehead collected these beetles from under rocks embedded in gravel at the margins of rivers in Mexico.

Life history.—Members of this species have been collected in all months, except February and October, but no teneral adults have been seen.

Distribution.—(Fig. 333). The range of this species extends from Sonora, south to Oaxaca on the west side of Mexico. I have seen 66 specimens from the following localities:

MEXICO

GUERRERO: (Rio Mezcala, 23.7 miles north of Zumpango) UASM; (Rio Papagayo, 41.4 miles north of Acapulco) UASM. NAYARIT: (Rio Acaponeta, 2.4 miles south of Acaponeta) UASM; (Rio de las Cañyas) CAS; (8.7 miles east of San Blas) GRNo; (19.0 miles southeast of Tepic) CAS. OAXACA: (Lago Tehuantepec, Benito Juarez Dam) UASM; (Rio Niltepec, 18.4 miles west of Zanatepec) UASM. SINALOA: (3.0 miles east of Culiacan) GRNo; (3.4 miles west, 5.0 miles south of Culiacan) GRNo; (12.0 miles south of Guasave) UASM; (Rio Panuco, 11.2 miles northeast of Concordia) UASM; (Venedio) CAS. SONORA: (7.2 miles southeast of Alamos) GRNo; (10.0 miles southeast of Alamos) UCD; (Rio Mayo, San Bernardo) CAS.

Figs. 304-307, 311. Pronotum, right half, dorsal aspect. 304. Brachinus cyanipennis Say, Milton, Vermont. 305. Brachinus galactoderus new species, Rio Papagayo, Guerrero, Mexico. 306. Brachinus gebhardis Erwin, Horse Creek, California. 307. Brachinus tenuicollis LeConte, Olcott, New York. 311. Brachinus medius Harris, Ritzville, Washington. Figs. 308-310, 312-323. Male genitalia. 308. Brachinus cyanipennis Say, Milton, Vermont, ventral aspect. 309. Lateral aspect of same. 310. Dorsal aspect of same. 312. Brachinus tenuicollis LeConte, Olcott, New York, ventral aspect. 313. Lateral aspect of same. 314. Dorsal aspect of same. 315. Brachinus medius Harris, Atbara, British Columbia, Canada, ventral aspect. 316. Lateral aspect of same. 317. Dorsal aspect of same. 318. Brachinus galactoderus new species, 12.0 miles south of Gusave, Sinaloa, Mexico, ventral aspect. 319. Lateral aspect of same. 320. Dorsal aspect of same. 321. Brachinus gebhardis Erwin, Gilroy Hot Springs, California, ventral aspect. 322. Lateral aspect of same. 323. Dorsal aspect of same. Accompanying scale lines equal 1.0 mm.


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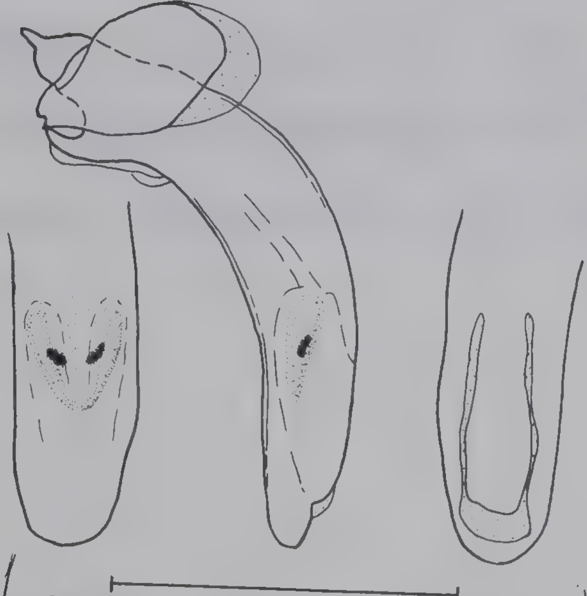
307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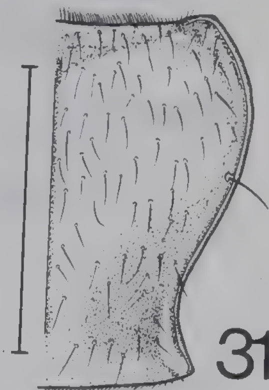
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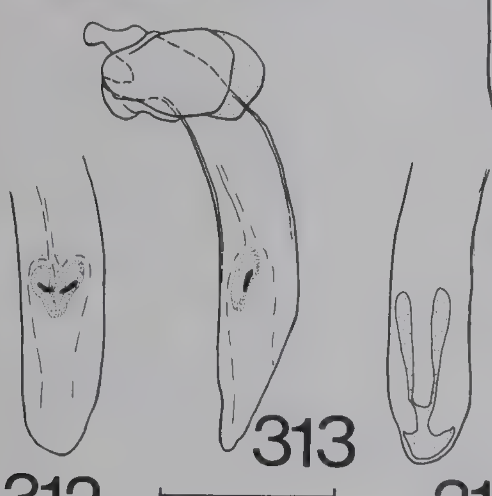
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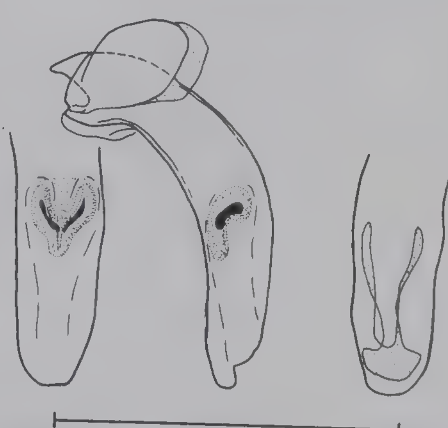
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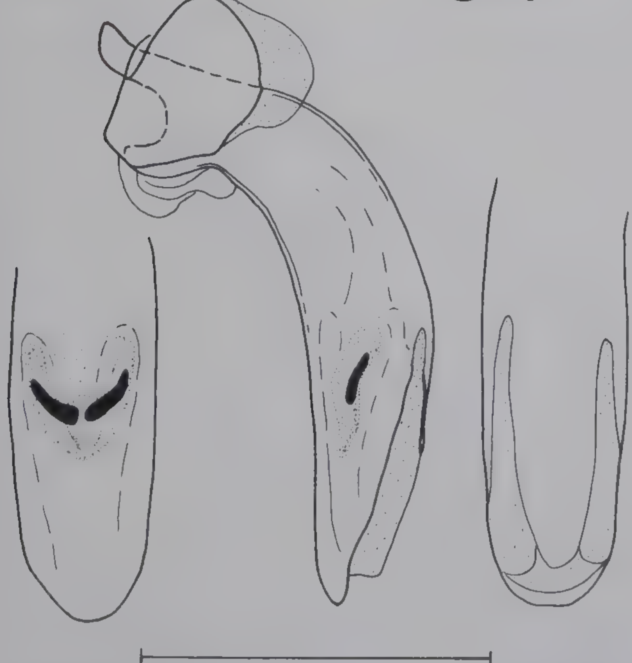
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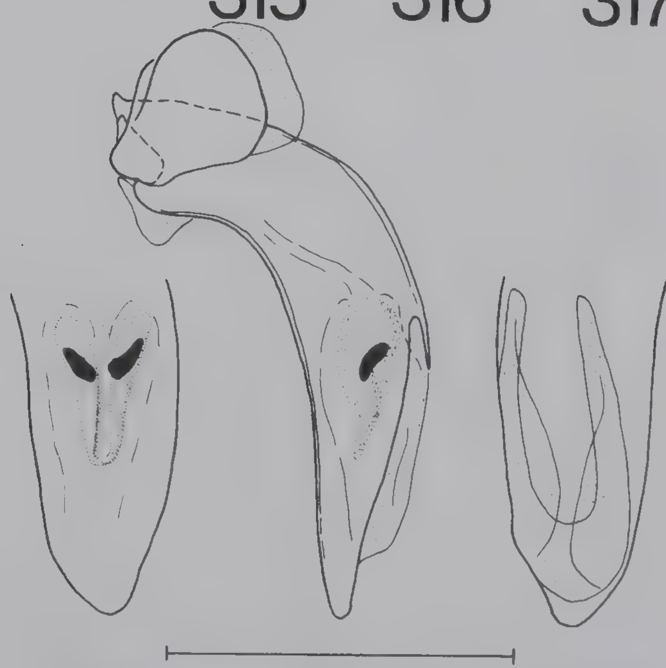
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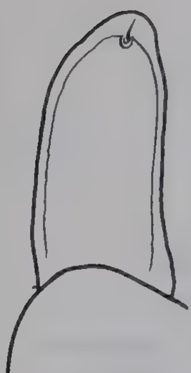
Figs. 324-328. Right stylus of female ovipositor, ventral aspect. 324. Brachinus tenuicollis LeConte, La Grange, Illinois. 325. Brachinus galactoderus new species, Lake Tehuantepec, Oaxaca, Mexico. 326. Brachinus cyanipennis Say, East Georgia, Vermont. 327. Brachinus gebhardis Erwin, Uvas Creek, California. 328. Brachinus medius Harris, McLeans Bogs, New York. Figs. 329-333. Geographical distribution maps. 329. Brachinus tenuicollis LeConte. 330. Brachinus cyanipennis Say. 331. Brachinus medius Harris. 332. Brachinus gebhardis Erwin. 333. Brachinus galactoderus new species. Accompanying scale line equals 1.0 mm.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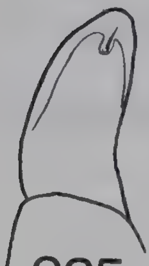
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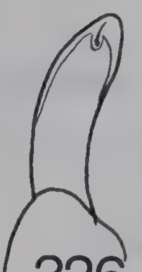
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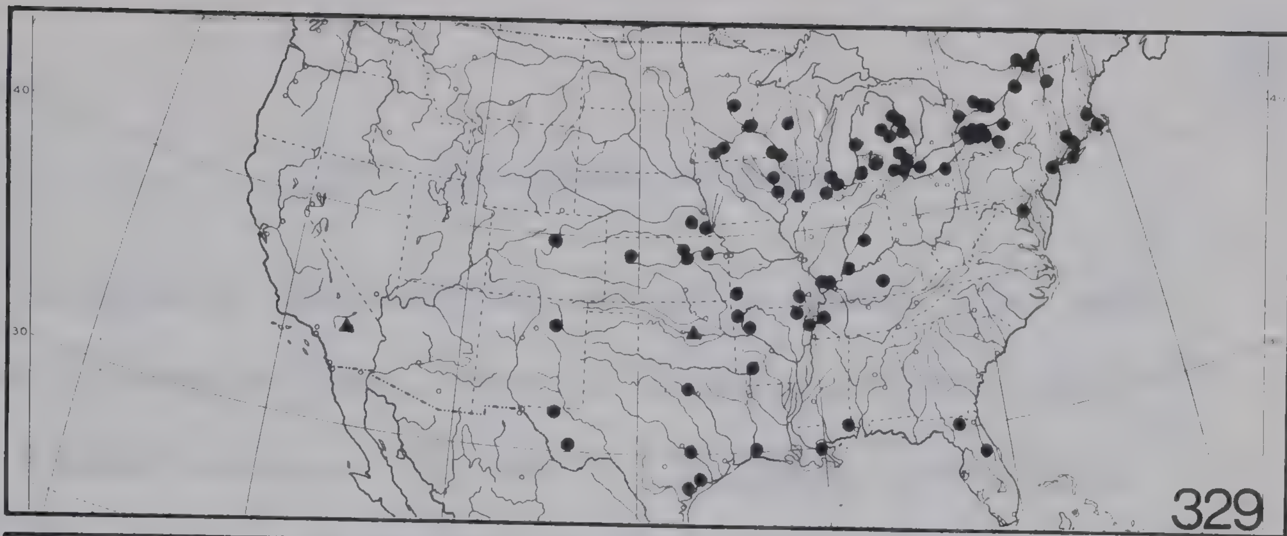
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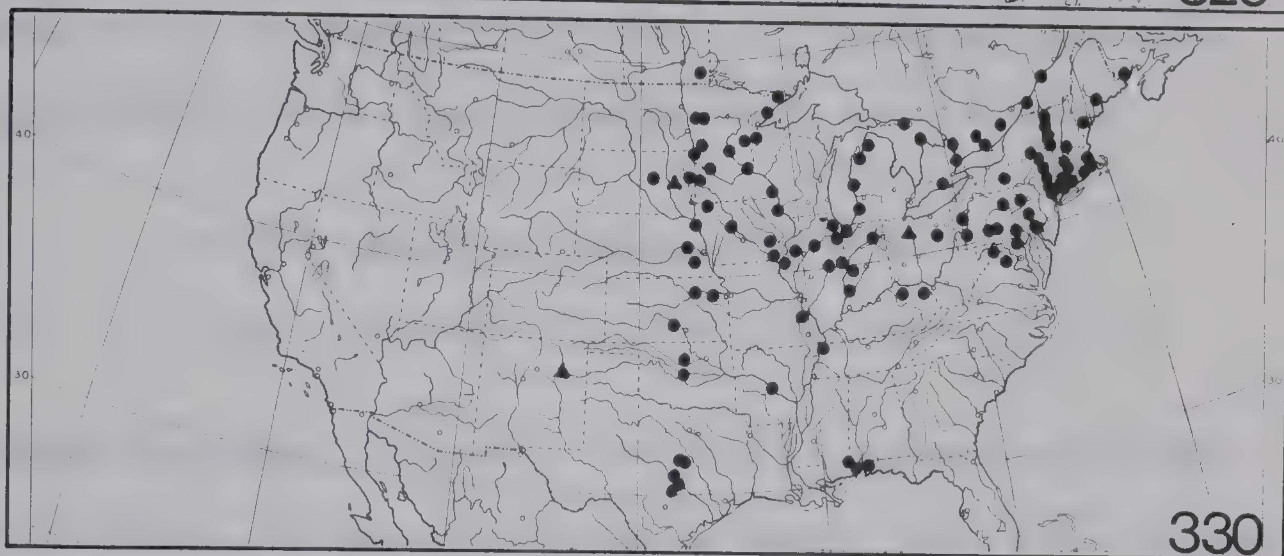
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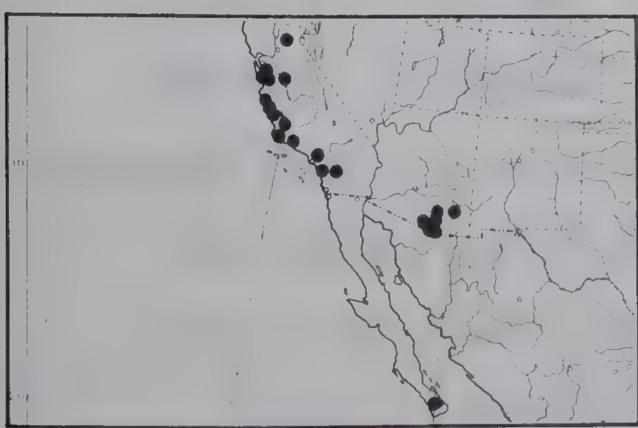
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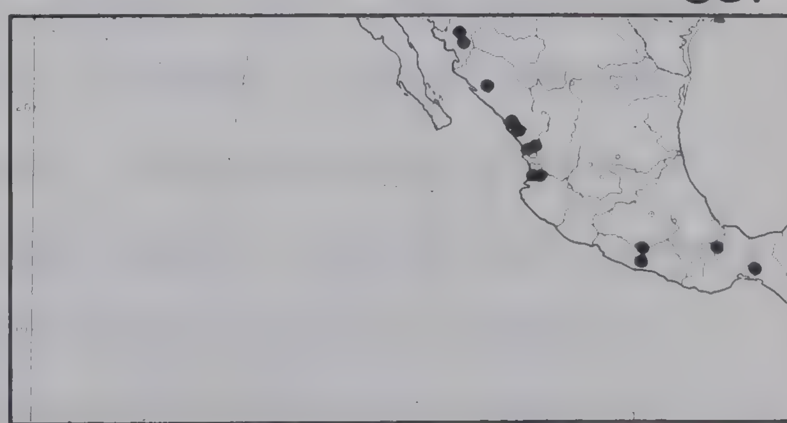
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4.622 The *fumans* subgroup

This subgroup is characterized by swollen median lobe, pale venter with infuscated sides, coarsely punctate pronotum, and generally similar habitus. Six species, *B. fumans* (Fabricius), *B. perplexus* Dejean, *B. puberulus* Chaudoir, *B. velutinus* Erwin, *B. favicollis* Erwin, and *B. imperialensis* Erwin, are included.

4.6221 *Brachinus fumans* (Fabricius)

(Figs. 334, 346, 347, 348, 358, 369)

Carabus fumans Fabricius, 1781:307. Lectotype, previously selected in Kiel Museum, box seven according to Zimsen (1964:61), labelled "in America, D. Blackburn."

Brachinus cyanopterus LeConte, 1844:49. Lectotype, here selected, a female, MCZ red type label number 5847, further labelled with a pink disc and "B. fumans Fab., Dej., cyanopterus Say." *Type locality*.—New York, as originally given by LeConte. LeConte 1848:203, LeConte 1862:524.

Brachinus sufflans LeConte, 1848:204. Lectotype, here selected, a female, MCZ red type label number 5648, further labelled with a pink disc and "86. v. sufflans LeC." *Type locality*.—New York, as originally given by LeConte. LeConte 1862:524.

Brachinus affinis LeConte, 1848:204. Lectotype, here selected, a male, MCZ red type label number unknown, further labelled with a yellow disc and "2747" and standing ninth in a series of 16 specimens behind box labelled "B. fumans Dej." *Type locality*.—Indiana, as originally given by LeConte. NEW

SYNONYMY.

Brachinus perplexus LeConte, 1862:524. This name must be considered a lapsus calami because LeConte (1848) correctly sites Dejean as author of this name. However, LeConte's concept of perplexus was different than that of Dejean, according to their labelled specimens.

Brachinus tabasconus Bates, 1891:268. Lectotype, here selected, a male, BMNH, labelled "San Jaun Bautista, Tabasco" and "Höge" and standing first behind label "tabasconus Bates." Type locality.—San Jaun Bautista, Tabasco, Mexico, as originally given by Bates. NEW SYNONYMY.

Brachinus amplipennis Bates, 1891:268. Lectotype, here selected, a female, BMNH, labelled "Paso del Norte, Chihuahua, Höge" "Tr. Ent. S. L. 1891. Brachinus amplipennis Bates" "Syntype" and "1891-64." Type locality.—Villa Lerdo, Durango, Mexico, as originally given by Bates. NEW SYNONYMY.

Brachinus atbarae Stehr, 1950:102. Holotype, a male, at OUCO, labelled "Atbara, B. C. Canada, 24-IV-45, G. Stace Smith Coll." Allotype, a female, at OUCO, labelled as holotype, except 7-V-46. Thirteen paratypes in OUCO and UBC. Type locality.—Atbara, British Columbia, Canada. NEW SYNONYMY.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 9.0 to 14.0 mm.

Color. Metepisterna, sides of abdominal sterna, and terga infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows, head behind eyes, and surface of pronotum rugose and punctate, punctures moderately impressed.

Head. Frontal furrows moderately impressed. Antennal scape robust, widened apically. Ligula with sclerotized center area ellipsoid-convex with two lateral rows of three setae per row. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 334) slightly convex, flattened along center line, sides slightly reflexed. Proepipleura and proepisterna with a few setae both anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior surface punctate, punctures elongate, sometimes merging.

Pterothorax. Elytra elongate, narrow, moderately costate. Humeral angle square or projecting. Costae smooth on disc, depressions pubescent. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 346, 347, 348). Median lobe with plane of shaft rotated about 45° from plane of basal bend. Basal bend short. Shaft swollen medially, very robust, apex blunt and slightly turned dorsally. Ligule short, broad, narrowed toward apex. Virga (figs. 346, 347). Female (fig. 358). Stylus narrow, parallel-sided, rounded apically.

Variation.—Intrapopulational variation occurs in the following characteristics: body size; shape of the pronotum; height of costae; length to width ratio of elytra; and color of terga. No clines are apparent.

Flight.—These beetles have been repeatedly collected at lights

in Arizona and Texas.

Etymology.—Latin, fumans = smoke; referring to the crepitating ability of these beetles.

Collecting notes.—D. R. Whitehead collected these beetles in gravel from under stones at the edges of an intermittent stream in Texas. In Colorado, C. Armin collected these beetles at lake and reservoir edges and along irrigation canals. In Arizona, these beetles were collected in wet meadows.

Life history.—Members of this species have been collected from March to October. Teneral adults were collected in British Columbia and Quebec in September.
Overwintering probably takes place as an adult.

Distribution.—(Fig. 369). The range of this species extends from Maine to Washington, south to Tabasco, Mexico. It is the most widespread species in North America. I have seen 2,055 specimens from the following localities:

CANADA

ALBERTA: (5.0 miles south of Etzikom) DRWh; (Lethbridge) UASM. BRITISH COLUMBIA: (Atbara, Creston) CUNY, UASM, ZMLS; (Rykerts, south of Creston) ZMLS. MANITOBA: (Aweme) UASM. ONTARIO: (Belleville) UASM; (Cedarvale) CAS; (Grand Bend, Lake Huron) ZMLS; (Ottawa) CNC; (Pelee Island) CNC, CUNY, PUM; (Port Hope) CAS; (Prince Edward County) CAS; (South Cajuga, southwest of Dunnville, Lake Erie) ZMLS; (Toronto) CAS, CUNY, USNM, ZMLS. QUEBEC: (Becancour) CCh; (Fort Coulonge) CNC; (Hull) CAS, USNM; (Ile Saint Helene) UASM; (Lachine) CAS; (Montreal) CAS, UWMW; (Outrem't) CAS; (Rigaud) HGou, ZMLS; (Saint Eustache) CAS; (Saint Foy) CCh; (Saint Jean) CAS;

(Saint Rose) CAS; (Vaudreuil) CAS.

MEXICO

CHIHUAHUA: (12.0 miles north of Escalon) CNC. COAHUILA: (Torreon) MCZ. NUEVO LEON: (Montemorelos) CAS; (Monterrey) AMNH; (5.0 miles south of Monterrey) CNC; (Rio Sabinos Hidalgo, 7.9 miles east of Sabinas Hidalgo) UASM. SAN LOUIS POTOSI: (Presa de Guadalupe, 55.3 miles west of Ciudad del Maiz) UASM. SINALOA: (12.0 miles south of Guasave) UASM; (5.0 miles north of Mazatlan) GRNo; (Real de Piaxtla) AMNH; (Venedio) CAS; SONORA: (Bahia San Francisquito) GRNo; (Hermosillo) CNHM; (Rio Mayo, San Bernardo) CAS. TAMAULIPAS: (Ciudad Mante) AMNH; (Ciudad Victoria) AMNH, CNHM; (Gomez Farias) UASM; (73.1 miles north of Manuel) UASM.

UNITED STATES

ALABAMA: Mobile County (Mobile) CAS; Tuscaloosa County (Tuscaloosa) UASM. ARIZONA: Cochise County (Cave Creek Ranch) UASM, (Douglas) UASM, (2.0 miles northeast of Douglas) OUCO, (South West Research Station, 5.0 miles west of Portal) CUNY, FDAG; Pima County (Tucson) AMNH, CAS, USNM; Pinal County (No locality given) JSch; Santa Cruz County (6.0 miles north of Nogales) UASM; County unknown (East Bridge) UMSP. ARKANSAS: Bradley County (No locality given) UAFA; Conway County (No locality given) UAFA; Garland County (Hotsprings) CAS; Greene County (No locality given) OSUC; Hempstead County (Hope) CUNY, MCZ, UMAH; Izard County (Franklin) ISUA; Lawrence County (Imboden) CAS, LACM, MCZ; Pulaski County (8.0 miles north of Camp Robinson) CNHM, (Little Rock) AMNH, MCZ; Pike County (Delight) CNHM; Washington County (No locality given) ISNH, UAFA. CALIFORNIA: San Diego County (No locality given) USNM; San Francisco County

(San Francisco) CMPP. COLORADO: Boulder County (Arvada) CArm, (Baseline Lake) CArm, (Bellmire Reservoir, Longmont) CArm, (Boulder Creek, near Boulder) CArm, (Hillcrest Lake) CArm, (Hodgson-Harris Reservoir, Louisville) CArm, (Lyons) CArm, (McIntosh, Longmont) CArm, (Prince Lake, Erie) CArm, (Reservoir Four Mile Mesa) CArm, (Valmont) CArm; Denver County (Denver) CAS, USNM; La Plata County (Durango) MCZ; Otero County (Rocky Ford) USNM; Weld County (Greeley) USNM. CONNECTICUT: Fairfield County (Danbury) AMNH, (Redding) UCR, (Stamford) USNM; New London County (Norwich) MCZ, (Old Lyme) CAS, USNM; (Windham County (Pomfret) CAS. DELAWARE: County unknown (Water Gap) AMNH, UASM. DISTRICT OF COLUMBIA: (Black Pond) USNM, (Piney Branch) USNM, (Rock Creek) USNM, (Woodridge) USNM. FLORIDA: Lake County (No locality given) UMAH; Orange County (Orlando) LACM. GEORGIA: Thomas County (Boston) TAMU. IDAHO: Boise County (2.0 miles west of Boise) CNHM, (Boise River, Boise) CNHM, UMAH; Bonner County (Sagle) UWSW; Canyon County (Homedale) CNHM, (Parma) UIMI, UMAH; Idaho County (Clearwater) WSUP; Latah County (Kendrick) UIMI, (Moscow) UIMI; Nez Perce County (Lewiston) OUCO, UIMI, (Myrtle) UIMI, (Snake River, 4.0 miles south of Lewiston) UIMI, (Spalding) UIMI. ILLINOIS: Alexander County (Olive Branch) CAS; Bureau County (Bureau) MCZ; Champaign County (Urbana) CNHM; Clark County (No locality given) PUM; Cook County (Chicago) CNHM, MCZ, WSUP, (La Grange) CAS, (Willow Springs) CAS; Greene County (Hillview) UCD; Kendall County (Oswego) CNHM; Lake County (Fort Sheridan) UMAH, (Highland Park) UMAH; La Salle County (Ottawa) RTBe; McHenry County (McHenry) JSch, WSUP; McLean County (Heyworth) USNM; Monroe County (Bloomington) UMAH; Pike County (Florence) UCD;

Putnam County (No locality given) ISNH; Richland and Lawrence Counties (Wabash) AMNH; Rock Island County (Moline) UMSP; Saint Clair County (No locality given) CAS; Sangamon County (Springfield) CNHM; Tazewell County (Tremont) CNHM; Vermilion County (Kickapoo State Park) RTBe, (Muncie) ISNH; Warren County (Pine) CMPP; Counties unknown (Falling Springs) LACM, (Saint Claire) LACM. INDIANA: Harrison County (No locality given) PUM; Lake County (Miller) CNHM, PUM; Porter County (Beverly Shores) CNHM; Posey County (Hovey Lake) CEWh, PUM, (Mount Vernon) CEWh; Steuben County (No locality given) PUM; Tippecanoe County (Lafayette) PUM. IOWA: Dickinson County (Lake Okoboji) USNM, (Spirit Lake) USNM; Guthrie County (8.0 miles southwest of Bayard) ISUA; Henry County (Mount Pleasant) CAS, ISUA, MCZ, RTBe, UASM, UMAH; Howard County (Elma) AMNH; Johnson County (Iowa City) CUNY, LACM, MCZ, USNM, (Solon) USNM; Iowa County (No locality given) MCZ; Palo Alto County (Ruthven) ISUA; Story County (Ames) CAS, GRNo, ISUA, MSUM, RTBe, USUL; Van Buren County (Lacey-Keosauqua State Park) ISUA; Woodbury County (Sioux City) UMSP; County unknown (Herrold) CAS. KANSAS: Atchison County (Atchison) CMPP; Clay County (No locality given) ANSP, USNM; Coffey County (No locality known) ULLK; Douglas County (Lawrence) UCD, UMAH, USNM, UWMW, (12.0 miles south of Lawrence) UCD; Ellis County (No locality given) KSU; Ellsworth County (Kanopolis Kam State Park) RCGr; Franklin County (No locality given) KSU, UMAH; Hamilton County (No locality given) CAS; Leavenworth County (Tonganoxie) MCZ; Montgomery County (Independence) CAS; Pottawatomie County (Onaga) CAS, KSU, OSUC; Riley County UIMI, (Manhattan) KSU; Rooks County (No locality given) KSU; Saline County (Salina) CMPP, KSU, MCZ; Shawnee County (Topeka)

CMPP; Wilson County (No locality given) LACM; Counties unknown (Fort Hays) MCZ, (Williston) MCZ. KENTUCKY: Jefferson County (Louisville) ULLK. MAINE: (No locality given) CNHM. MARYLAND: Montgomery County (Cabin John) USNM; Prince Georges County (College Park) UMCP; County unknown (Plummers Islands) USNM. MASSACHUSETTS: Barnstable County (Barnstable) MCZ, (Woods Hole) JSch, USNM; Bristol County (Fall River) CAS, (Somerset) CAS; Dukes County (Martha's Vineyard) USNM; Essex County (Manchester) MCZ, (Topsfield) UASM; Franklin County (Northfield) MCZ, ZMLS; Hampden County (Chicopee) MCZ, (Springfield) MCZ, ZMLS; Hampshire County (Mount Tom) CMPP; Middlesex County (Billercia) CAS, UATA, (Cambridge) CAS, MCZ, (Concord) MCZ, (Tyngsboro) CAS, MCZ; Nantucket County (Nantucket) ISNH; Norfolk County (Brookline) AMNH, (Newton) MCZ, (Wellesley) MCZ; Plymouth County (Duxbury) MCZ, (Marion) MCZ; Suffolk County (Dorchester) MCZ, ZMLS; County unknown (Forest Hills) USNM. MICHIGAN: Huron County (Charity Island) UMAH; Livingston County (E. S. George Reserve) UMAH; Oceania County (Pentwater) UMAH; Wayne County (Detroit) USNM; Washtenaw County (Ann Arbor) UMAH; (Sharon) UMAH. MISSOURI: Atchison County (Langdon) AMNH; Buchanan County (Saint Joseph) USNM; Greene County (Willard) ANSP, UASM; Jackson County (Buckner) TAMU; Pettis County (Sedalia) CNHM; Platte County (Parkville) ISUA; Saint Charles County (Saint Charles) MCZ; Saint Louis County (Saint Louis) CAS, (Valley Park) UMAH; Vernon County FDAG, (Nevada) TLEr; County unknown (Big Oak State Park) RTBe. MINNESOTA: Benton County (No locality given) UMSP; Big Stone County (No locality given) UMSP; Clearwater County (Bohall, Lake Itasca State Park) UMSP, (De Soto Lake, Itasca State Park) UMSP; Douglas County

(Alexandria) PSUU; Goodhue County (Lake Pepin, east of Frontenac) UMSP; Hennepin County (Minneapolis) UMSP; Houston County (near Brownsville) UMSP; Olmstead County (No locality given) UMSP; Norman County UMSP, (Ada) USNM; Pine County UMSP, (Snake River, 4.0 miles east of Pine City) USNM; Ramsey County (Saint Paul) ISNH, UMSP; Saint Louis County (Park Point, Duluth) AMNH; Stearns County (Lake Koronis, Paynesville) USNM; Traverse County (No locality given) UMSP; Washington County (3.0 miles south of Afton) UMSP, (Saint Croix River) UMSP; County unknown (Cliff) UMSP. MONTANA: Lake County (Polson) UWSW; Liberty County (Chester) MSUM; Mineral County (6.0 miles southeast of Saint Regis) LRus; Sanders County (Paradise) LRus; Stillwater County (Columbus) MSUM. NEBRASKA: Cass County (South Bend) UNLN, USNM; Dakota County (South Sioux City) UNLN; Lancaster County (Lincoln) CAS, UNLN, (Malcolm) CAS, USNM, (Roca) UNLN; Nemaha County (Peru) LSUB; Nuckolls County (Superior) OSUC; Otoe County (Nebraska City) UNLN; Saunders County (Ashland) SDSU, (Cedar Bluffs) UNLN; Thomas County (Halsey) UMAH, UNLN. NEVADA: Humboldt County (Golconda) CBak. NEW HAMPSHIRE: Cheshire County (Jaffrey) MCZ; Grafton County (Hanover) USNM; Strafford County (Durham) ISNH. NEW JERSEY: Bergen County (Demarest) USNM, (Emerson) CAS, (Fort Lee) AMNH, (Palisade) MCZ, (Ramsey) AMNH; Camden County (Clementon) USNM; Cape May County (Seven Mile Beach) OUCO; Essex County (South Orange) CAS; Gloucester County (Glassboro) USNM, (Grenloch) USNM, (Malaga) ANSP; Morris County (Boonton) USNM, (Chester) AMNH; Middlesex County (South Amboy) AMNH; Passaic County (Clifton) USNM, (Oak Ridge) CNHM, (Passaic) AMNH, (Paterson) AMNH; Somerset County (No locality given) USNM; Sussex County (Hopatcong) AMNH;

Warren County (Phillipsburg) CAS; Counties unknown (Estling Lake) USNM, (Gugmard) AMNH, (Midvale) USNM, (Snake Hill) USNM. NEW MEXICO: Sandoval County (Los Alamos) CNC. NEW YORK: Albany County (Altamont) CUNY; Columbia County (Copake Falls) CNHM; Cortland County (McLean Bogs) CAS, CUNY, ISNH, UMCP; Delaware County (Cooks Falls) CAS; Dutchess County (Poughkeepsie) UASM; Erie County (Buffalo) ISNH; Niagara County (Olcott) AUAA; New York County (Bronx Park) AMNH, (Flatbush) AMNH, (Mosholu) AMNH, (Nepera Park) CAS, (New York City) CAS, MCZ, (Parkville) AMNH, (Rattlesnake Creek) CAS, (Staten Island) AMNH, CAS, USNM, (Yonkers) MCZ; Orange County (Huguenot) AMNH, (Pine Island) CUNY, (West Point) USNM; Queens County (Jamaica) AMNH, MCZ; Rockland County (Suffern) USNM; Saint Lawrence County (Rossie) JSch; Tompkins County (Ithaca) CAS, CUNY, KSU, OUCO, PSUU, UASM, UMCP, UNLN, (McLean) UMSP; Ulster County (Ashokan) AMNH (Oliverea) USNM; Wayne County (Sodus) UASM; Westchester County (New Rochelle) CAS, (Peekskill) MCZ, (White Plains) CAS, USNM; County unknown (Catskill) CAS, (Danby) UNLN. NORTH CAROLINA: Beaufort County (Washington) MCZ; Haywood County (Mount Sterling) CAS; Moore County (Southern Pines) USNM; New Hanover County (Wilmington) CAS; Pasquotank County (Elizabeth City) MCZ; Polk County (Tryon) USNM; Robeson County (Lumberton) CNC; County unknown (Faison) CNC. OHIO: Ashtabula County (Chestnut Grove) PUM, (Jefferson) PUM, (Rock Creek) PUM, (Saybrook) PUM; Hamilton County (Cincinnati) UMAH; Ottawa County (Bass Island) PUM, (Put-in-Bay) UMAH; Putnam County (Sugar Creek) PUM; Summit County (Hudson) MCZ. OKLAHOMA: Cleveland County (Norman) OSUS, (Uono) CAS; Delaware County (Jay) OSUS; McCurtain County (Idabel) OSUS; Oklahoma County (No locality given) OSUS;

Payne County (Stillwater) OSUS; Rogers County (Catoosa) CNHM; Tulsa County (Tulsa) CAS. OREGON: Baker County (Robinette) UWSW, (Snake River, Farewell Bend) UWSW; Douglas County (Roseburg) MCZ; Gilliam County (5.0 miles west of Arlington) JSch; Malheur County (Ontario) UWSW; Umatilla County (Camp Umatilla) MCZ; Union County (Alicel) RESt, UIMI; Wallaowa County (Wallaowa) OSUC; Wasco County (The Dalles) MCZ; County unknown (Olds Ferry) UIMI. PENNSYLVANIA: Allegheny County CAS, (Pittsburgh) CMPP; Bradford County (Susquehanna River, Wyalusing) UASM; Centre County (State College) PSUU; Chester County (Unionville) CMPP; Dauphin County (Harrisburg) UASM, (Hemmelstown) ANSP; Delaware County (Castlerock) USNM; Fayette County (No locality given) CMPP; Luzern County (Wyoming) USNM; Monroe County (Echo Lake) CAS; Northampton County (Easton) CAS, (Water Gap) AMNH; Philadelphia County (Olney) USNM, (Philadelphia) USNM; Pike County (Milford) CNHM; Tioga County UMAH, (Rutland) ANSP; Wayne County (White Mills) CAS; Westmoreland County (Jeannette) CMPP; Counties unknown (Conk Forest) PSUU, (Edge Hill) USNM, (Rockville) CAS, (The Rock) PSUU. RHODE ISLAND: Kent County (Quonset Point) CAS, (Warwick) UMAH; Newport County (Newport) USNM, (Portsmouth) CAS; Providence County (Providence) CMPP; Washington County (Watch Hill) USNM; County unknown (Touisset) UMAH. SOUTH CAROLINA: Oconee County (Clemson) WSUP. SOUTH DAKOTA: Brookings County (Brookings) CMPP, SDSU, VMKi, (Volga) CAS; Hughes County (Canning) SDSU, (Pierre) SDSU, VMKi; Tripp County (Winner) VMKi. TENNESSEE: Lake County (Gray's Lodge) RTBe; Monroe County (Unaka Mountains) ANSP; Morgan County (Burrville) CNHM; Counties unknown (Lookout Mountain) MCZ, (Reelfoot Lake) CUNY, ISNH. TEXAS: Bexar County (San Antonio) CUNY, (10.0 miles northwest of San Antonio)

CAS; Blanco County (Round Mountain) CAS; Brazos County ISNH, (College Station) TAMU; Brewster County (Castolon) TAMU, (Glenn Springs) UMAH; Cameron County (Brownsville) CAS, CUNY, DHKa, MCZ, USNM, (Esperanza Ranch, Brownsville) USNM; Comal County (New Braunfels) UASM; Dallas County (Dallas) MCZ, UASM; Dimmit County (No locality given) TAMU; Hidalgo County (Mission) UASM, (Weslaco) TAMU; Kleburg County (Kingsville) CUNY; Lamar County (Paris) USNM; Lee County (Fedor) CMPP; Reeves County (Balmorhea Lake) UASM, (Pecos) ISUA; Taylor County (Abilene) CAS; Terrell County (Lozier Canyon) MCZ; Travis County (Austin) UASM; Uvalde County (Uvalde) CAS; Val Verde County (Del Rio) UASM, (Devil's River, Del Rio) CNC, (9.0 miles southeast of Del Rio) DRWh; Victoria County (Victoria) USNM; Webb County (Laredo) CAS. UTAH: Cache County (Logan) USUL, (Wellsville) USUL; Salt Lake County (Fort Douglas) MCZ; Uinta County (No locality given) CMPP; Utah County (Provo) CAS; Weber County (Ogden) CNHM, USNM. VERMONT: Bennington County (No locality given) CAS, MCZ, USNM; Chittenden County (Burlington) RTBe; Franklin County (La Moille River, East Georgia) RTBe; Lamoille County (Stowae) AMNH; Windsor County (White River Junction) CAS. VIRGINIA: Fairfax County MCZ, (Alexandria) USNM, (Great Falls) USNM; Loudon County (Bluemont) USNM, (Harpers Ferry) USNM; Montgomery County (No locality given) USNM; Nelson County (No locality given) USNM; Spotsylvania County (Fredericksburg) CAS. WASHINGTON: Adams County (Lake McElroy) CAS, PUM, USNM, (Lind) CAS, (Ritzville) USNM; Asotin County (Grande Ronde River, Anatone) UWSW; Benton County (Hanford) UWSW; Franklin County (Kahlotus) CAS, UWSW, (Pasco) UWSW, WSUP; Grant County (Coulee City) CAS, UWSW, (Dry Falls, Grand Coulee) UWSW, WSUP, (Stratford)

CAS, UIMI, USNM, UWSW; Kittisas County (Vantage) CAS, UWSW; Lincoln County (Sprague) USNM, (Sprague Lake) CAS; Pend Oreille County (Usk) USNM; Spokane County (Cheney) WSUP; Walla Walla County (Burbank) UWSW, (College Place) JSch; Whitman County (Almota) WSUP, (Wawawai) USNM, UWSW, WSUP; Counties unknown (Vila) UWSW, (Yakima River, Morgan's Ferry) MCZ. WEST VIRGINIA: USNM, Tucker County (No locality given) SJSC. WISCONSIN: Bayfield County (No locality given) UWMW; Dane County (No locality given) UWMW, UWSW; Dodge County (Beaver Dam) CAS, UMAH; Green County (Albany) CAS, (Brodhead) UMAH; Milwaukee County (Milwaukee) MCZ; Sauk County (Praire du Sac) CNHM. WYOMING: (No locality given) CMPP.

4.6222 _Brachinus puberulus_ Chaudoir

(Figs. 337, 355, 356, 357, 360, 368)

Brachinus puberulus Chaudoir, 1868:294. Lectotype, here selected, a male, MHNP, labelled "stygicornis sec. LeConte Say" and "Ex Museo Chaudoir." _Type locality_.—Texas, as originally given by Chaudoir.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 9.5 to 12.4 mm.

Color. As in _fumans_.

Microsculpture. As described for genus.

Macrosculpture. As in _fumans_, except punctures finer.

Head. As in _fumans_, except antennal scape widest at middle.

Prothorax. As in _fumans_, except anterior tibia with anterior surface strigose. Pronotum (fig. 337).

Pterothorax. As in <u>fumans</u>, except costae weaker.

Abdomen. As described for genus.

Genitalia. Male (figs. 355, 356, 357). Median lobe with plane of shaft barely rotated from plane of basal bend. Basal bend short. Median lobe swollen medially. Apex of shaft narrow, slightly turned dorsally. Ligule short, parallel-sided, rounded apically. Virga (figs. 355, 356). Female (fig. 360). Stylus long, narrow, rounded apically.

<u>Variation</u>.—Too few specimens are known to evaluate geographic variation.

<u>Flight</u>.—The flight of these beetles has not been recorded.

<u>Etymology</u>.—Latin, <u>pubis</u> = down or hair; <u>ulus</u> = diminutive; referring to the short pubescence covering these beetles.

<u>Life history</u>.—I have seen one adult collected in May, but it was not teneral.

<u>Distribution</u>.—(Fig. 368). This species is known only from Texas. I have seen six specimens from the following localities:

UNITED STATES

TEXAS: MCZ, MHNP, Cameron County (Brownsville) WHTy; Hidalgo County (No locality given) TAMU; Victoria County (Victoria) USNM.

4.6223 <u>Brachinus favicollis</u> Erwin
(Figs. 336, 340, 341, 342, 359, 365)

<u>Brachinus favicollis</u> Erwin, 1965:11. Holotype male and allotype female both in CAS. <u>Type locality</u>.—Jamul, San Diego County California.

<u>Diagnostic combination</u>.—The very deep punctures of the pronotum

separate these beetles from others in the study area.

Description.—Medium-sized beetles, 9.5 to 10.5 mm.

Color. As in fumans, except terga ferrugineous, and sterna more narrowly infuscated at side.

Microsculpture. As described for genus.

Macrosculpture. As in fumans, except pronotal punctures much deeper.

Head. As in fumans, except mentum and submentum with accessory setae.

Prothorax. Pronotum (fig. 336) similar to fumans. Proepipleura and proepisterna with numerous scattered setae. Anterior tibia with anterior surface strigose.

Pterothorax. As in fumans, except costae more highly elevated.

Abdomen. As described for genus.

Genitalia. Male (figs. 340, 341, 342). Median lobe with plane of shaft rotated about 45° from plane of basal bend. Basal bend short. Shaft not as swollen as in fumans, apex more narrowed and slightly twisted. Ligule short, broad, truncate. Virga (figs. 340, 341). Female (fig. 359). Stylus narrow, widened apically and rounded.

Variation.—Intrapopulational variation occurs in the shape of the pronotum, the color of the elytra, and the degree to which the metepisterna are infuscated.

Flight.—These beetles have been collected at lights at Camp Verde, Arizona.

Etymology.—Latin, favus = honeycomb; collis = neck; referring to the strongly punctured pronotum of these beetles.

Collecting notes.—D. R. Whitehead collected these beetles at

the edge of a permanent stream near Hooker's Hot Springs, Arizona. G. R. Noonan collected specimens from under stones in an intermittent stream bed in southern California at an elevation of 3,250 feet. The stream side was sandy and with small stones. The common trees in the bottom of the gully, through which the stream flowed, were specimens of <u>Plantanus</u>, <u>Salix</u>, <u>Alnus</u>, <u>Populus</u>, and <u>Fraxinus</u> species.

<u>Life history</u>.—Members of this species have been collected from March to August, and in January and October. Teneral adults were collected in May in California and Arizona, and in July in Arizona. Overwintering probably takes place in the adult stage.

<u>Distribution</u>.—(Fig. 365). The range of this species extends from eastern Arizona into California, and south to Baja California. I have seen 152 specimens from the following localities:

MEXICO

BAJA CALIFORNIA: (Cataviña) CAS; (San Vincente) LACM; (South of El Sauzal) CAS.

UNITED STATES

ARIZONA: Cochise County (Bass Canyon, Tenney's Mule Shoe Ranch, near Hooker's Hot Springs) DRWh; Gila County (East Verde River, 6.0 miles north of Payson) LACM, (10.0 miles south of Globe) AMNH, (base of Pinal Mountains) PUM, UATA; Graham County (Geronimo) UATA; Navajo County (8-15.0 miles northeast of Whiteriver) AMNH; Pima County (Santa Catalina Mountains) CAS, (Tucson) CAS, UATA; Pinal County (Aravaipa Creek) CUNY; Yavapai County (Camp Verde) CAS, (Cottonwood) UIMI; County unknown (Carrizo) UATA, (Kohl's Ranch) UATA. CALIFORNIA: Imperial County (Carrizo) UMAH; Los Angeles County CMPP, (Azusa) LACM, (Los Angeles) LACM, (Pasadena) CAS,

(San Francisquito Canyon) LACM, (San Gabriel Canyon) GRNo, (Tujunga Creek) LACM; Orange County (Black Star Canyon) UCD, (Trabuco) GRNo; Riverside County (Hemet) VVBa, (Palm Canyon) CNC, LACM, MCZ, (Palm Springs) UCD, (Temecula) CAS; San Bernardino County (Mojave River) CAS; San Diego County UCD, (Jamul) CAS, (Mission Valley) SDNHM, (Pamo Valley) LACM, (Poway Groove) GRNo; Santa Barbara County (4.0 miles east of Los Prietos) UCD; County unknown (San Juan) UWSW.

4.6224 Brachinus perplexus Dejean
(Figs. 335, 343, 344, 345, 362, 366)

Brachinus perplexus Dejean, 1831:426. Lectotype, here selected, a male, MHNP, labelled "perplexus ? var. in Amer. bor." on green paper, and "Ex Museo Chaudoir" on white paper. This specimen stands first in second row of nine specimens. Type locality.—North America, as originally given by Dejean, but herewith restricted to Florida.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 7.9 to 11.0 mm.

Color. As in fumans, except terga usually ferrugineous.

Microsculpture. As described for genus.

Macrosculpture. As in fumans.

Head. As in fumans, except antennal scape widest about middle, and mentum and submentum with accessory setae.

Prothorax. As in fumans, except anterior tibia with anterior surface strigose. Pronotum (fig. 335).

Pterothorax. As in fumans, except costae weaker and more

densely punctate, and humeral angle not so prominent.

Abdomen. As described for genus.

Genitalia. Male (figs. 343, 344, 345). Median lobe with plane of shaft rotated 45° from plane of basal bend. Basal bend long. Apex of shaft narrow, slightly twisted. Ligule moderately long, broad, truncate. Virga (figs. 343, 344). Female (fig. 362). Stylus short, broad, slightly bent at apical third, narrowly rounded apically.

Variation.—Intrapopulational variation occurs in the body size and in the shape of the pronotum.

Flight.—These beetles have been collected at lights in Alabama and Louisiana.

Etymology.—Latin, perplexus = intricate, puzzling; referring to the similarity of these beetles to the other species in the genus.

Life history.—Members of this species have been collected in February, and May to August, but no teneral adults have been seen.

Distribution.—(Fig. 366). The range of this species extends from Florida to Texas, and north to southern Iowa. I have seen 71 specimens from the following localities:

UNITED STATES

ALABAMA: Mobile County (Mobile) CAS; Tallapoosa County (Smith Mountain Tower) AUAA. ARKANSAS: Conway County (No locality given) UAFA; Desha County (No locality given) UAFA; Hempstead County (Hope) MCZ; Lawrence County (No locality given) CAS. FLORIDA: Dade County (Royal Palm State Park) PUM; Pinellas County (Tarpon Springs) CAS. LOUISIANA: Ouachita Parish (Calhoun) UAFA; Vernon Parish (Rosepine) UAFA. MISSISSIPPI: Carrol County (Avalon) UMAH; George County

(Lucedale) CUNY; Pike County (McComb) UWSW; Tunica County (Dundee) UMAH. NORTH CAROLINA: Moore County (Southern Pines) CNC. OKLAHOMA: Le Flore County (Summerfield) OSUS. TENNESSEE: Lake County (Gray's Lodge) RTBe; Shelby County (Memphis) CAS. TEXAS: Dallas County (Dallas) MCZ; Kleberg County (Kingsville) CUNY; Morris County (Daingerfield State Park) UASM; Victoria County (Victoria) USNM; County unknown (Fuller) USNM.

4.6225 *Brachinus velutinus* Erwin

(Figs. 339, 352, 353, 354, 363, 367)

Brachinus velutinus Erwin, 1965:17. Holotype male and allotype female both in UCD. *Type locality*.—Davis, Yolo County, California.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Small-sized beetles, 7.0 to 8.2 mm.

Color. As in *fumans*, except terga and metepisterna usually ferrugineous.

Microsculpture. As described for genus.

Macrosculpture. As in *fumans*, except punctures very fine.

Head. As in *fumans*, except antennal scape almost cylindrical, and mentum with accessory setae.

Prothorax. As in *fumans*, except much narrower, proepipleura and proepisterna pubescent throughout, and anterior tibia with anterior edge strigose. Pronotum (fig. 339).

Pterothorax. Elytra narrower than in *fumans*, more sloped at humeri, costae hardly present, and with denser pubescence.

Abdomen. As described for genus.

Genitalia. Male (figs. 352, 353, 354). Median lobe with plane of shaft rotated about 45° from plane of basal bend. Basal bend short. Median lobe slightly swollen medially. Apex of shaft narrowed, slightly twisted, and slightly bent dorsally. Ligule short, narrow, and rounded apically. Virga (figs. 352, 353). Female (fig. 363). Stylus short, broad, arcuate, narrowly rounded apically.

Variation.—Too few specimens are known to evaluate geographic variation.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Latin, *velutinus* = velvety; referring to the velvety-down appearance of the elytral pubescence on these beetles.

Collecting notes.—W. H. Tyson collected members of this species in a *Typha*-*Scirpus* marsh near Los Banos when the water was near maximum height.

Life history.—Members of this species have been collected in April, May, and September, but no teneral adults were seen.

Distribution.—(Fig. 367). The range of this species extends along the Central Valley of California in the Sacramento and San Joaquin drainage systems. I have seen 19 specimens from the following localities:

UNITED STATES

CALIFORNIA: PUM, USNM, Contra Costa County (Brentwood) CAS; Stanislaus County (Newman) UCD; Tulare County (Visalia) UCD; Yolo County (Davis) CAS, UCD.

4.6226 Brachinus imperialensis Erwin

(Figs. 338, 349, 350, 351, 361, 364)

Brachinus imperialensis Erwin, 1965:17. Holotype and allotype both in CAS. Type locality.—Potholes, Imperial County, California.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 7.0 to 12.1 mm.

Color. Metepisterna and sides of abdominal sterna infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. As in fumans.

Head. As in fumans, except antennal scape widest at middle, and mentum and submentum with accessory setae.

Prothorax. As in fumans, except anterior tibia with anterior surface strigose.

Pterothorax. As in fumans, except costae weaker and elytra totally pubescent.

Abdomen. As described for genus.

Genitalia. Male (figs. 349, 350, 351). Median lobe with plane of shaft rotated about 45^{o} from plane of basal bend. Basal bend short. Apex of shaft broad, slightly twisted. Ligule moderately long, broad, rounded apically. Virga (figs. 349, 350). Female (fig. 361). Stylus short, arcuate, rounded apically.

Variation.—Intrapopulational variation occurs in body size and in the shape of the pronotum.

Flight.—These beetles have been collected repeatedly at lights throughout the range of the species.

Etymology.—Imperial, English, from Imperial County, the place where the types were collected; ensis = place, locality, or country.

Life history.—Members of this species have been collected in March and April, June to September, and November, but teneral adults were not seen.

Distribution.—(Fig. 364). The range of this species extends from eastern Colorado, south to the Mexican Highplain, and from California east to Texas. I have seen 218 specimens from the following localities:

MEXICO

DURANGO: (Durango) AMNH; (Tlahuahlo) USNM. SAN LUIS POTOSI: (San Luis Potosi) AMNH. SINALOA: (Los Mochis) CAS. SONORA: (Ciudad Obregon) AMNH; (Hermosillo) CAS.

UNITED STATES

ARIZONA: Cochise County (Cave Creek Ranch) SJSC, UASM; (Douglas) CNHM, CUNY, FDAG, UASM, UCD, UCR; (2.0 miles northeast of Douglas) OUCO; (5.0 miles west of Portal) UCD; (South West Research Station, 5.0 miles west of Portal) AMNH, CUNY; Coconino County (Cameron Trading Post) UASM; Graham County (Thatcher) UCD; Pima County (San Simon) LACM; (Tucson) MCZ, USNM; Yuma County (Fort Yuma) USNM, (Yuma) CAS, MCZ, TLEr, TMBH, UATA, USNM; County unknown (East Bridge) ISUA, MCZ. CALIFORNIA: Imperial County (Brawley) CAS, CBak, (Calexico) UCD, UWSW, (Calipatria) CAS, (El Centro) CAS, CNHM, TLEr, (Holtville) CAS, (Imperial Valley) UATA, (Needles) TLEr, (Palo Verde) UIMI, (Potholes) CAS; Los Angeles County (No locality given) CAS, UWSW;

Riverside County (Blythe) CAS, (Colorado River, Blythe) TLEr, (Lake Elsinore) USMN, (Palm Springs) USMN. COLORADO: Yuma County (Wray) KSU. NEVADA: Clark County (Logandale) NSDA, (Overton) UASM, (Overton Boat Landing) JSch. NEW MEXICO: Curry County (Clovis) USNM; Hidalgo County (Animas) AMNH, (Rodeo) CUNY; Luna County (Deming) MCZ. TEXAS: Brewster County (Alpine) CAS, (Castolon) TAMU; Cameron County (Brownsville) CNC, CUNY, ISNH; El Paso County (El Paso) CMPP; Hidalgo County TAMU, (McAllen) UMAH; Jeff Davis County (Fort Davis) CNC; Kleberg County (Kingsville) CUNY; Randall County (Canyon) TAMU, (Palo Duro State Park) UMSP; Reeves County (Pecos) ISUA; San Patricio County (Welder Wildlife Refuge, near Sinton) CNC; Travis County (Austin) UASM; Victoria County (Victoria) UASM.

Figs. 334-339. Pronotum, right half, dorsal aspect. 334. Brachinus fumans Fabricius, Kahlotus, Washington. 335. Brachinus perplexus Dejean, Dundee, Mississippi. 336. Brachinus favicollis Erwin, Jamul, California. 337. Brachinus puberulus Chaudoir, Victoria, Texas. 338. Brachinus imperialensis Erwin, Douglas, Arizona. 339. Brachinus velutinus Erwin, Davis, California.

Figs. 340-345. Male genitalia. 340. Brachinus favicollis Erwin, Jamul, California, ventral aspect. 341. Lateral aspect of same. 342. Dorsal aspect of same. 343. Brachinus perplexus Dejean, Dundee, Mississippi, ventral aspect. 344. Lateral aspect of same. 345. Dorsal aspect of same. Accompanying scale lines equal 1.0 mm.

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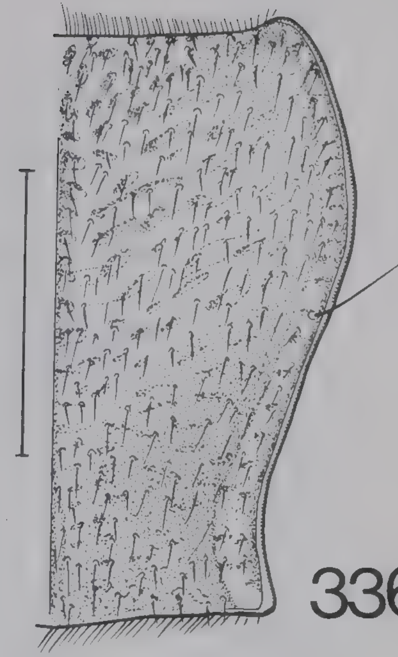

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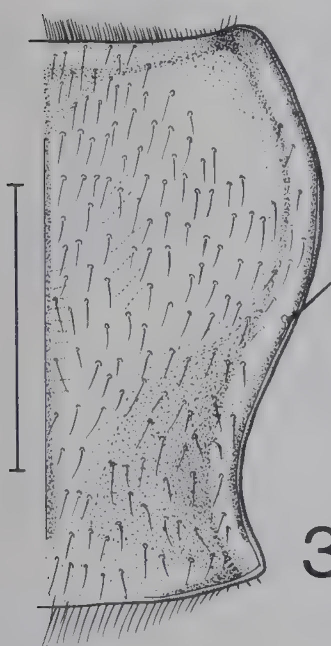

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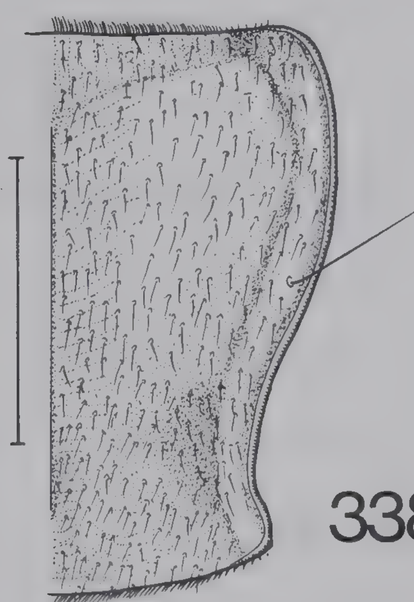

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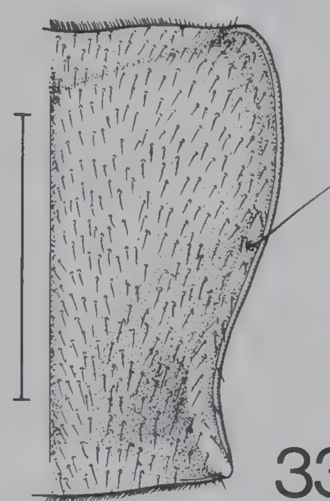

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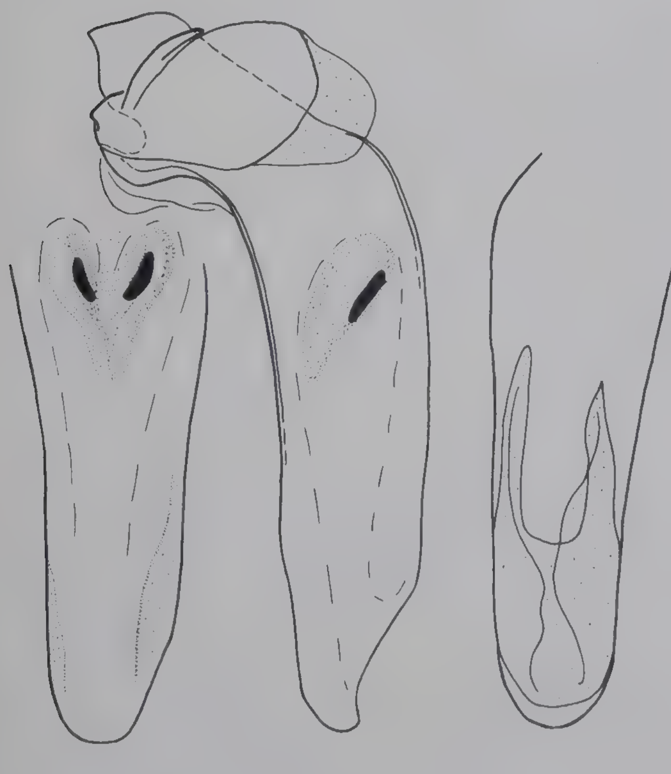

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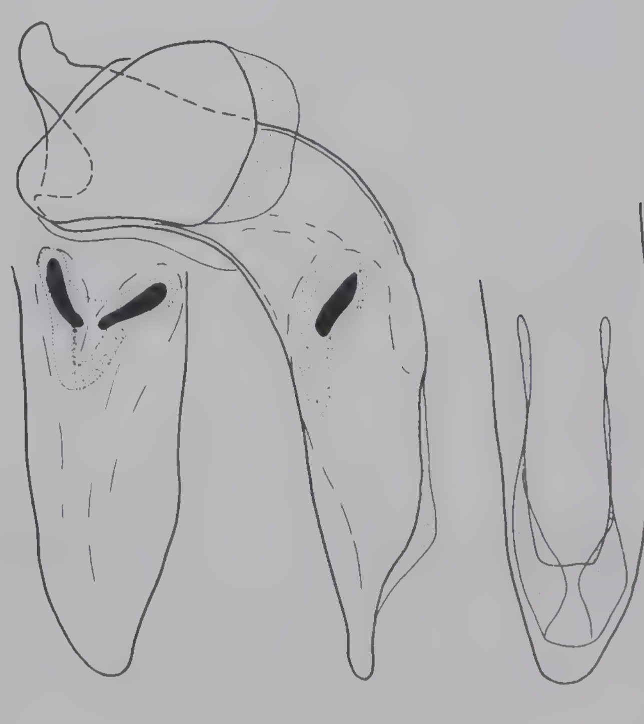

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Figs. 346-357. Male genitalia. 346. _Brachinus fumans_ Fabricius, Vantage, Washington, ventral aspect. 347. Lateral aspect of same. 348. Dorsal aspect of same. 349. _Brachinus imperialensis_ Erwin, Douglas, Arizona, ventral aspect. 350. Lateral aspect of same. 351. Dorsal aspect of same. 352. _Brachinus velutinus_ Erwin, Davis, California, ventral aspect. 353. Lateral aspect of same. 354. Dorsal aspect of same. 355. _Brachinus puberulus_ Chaudoir, Hidalgo County, Texas, ventral aspect. 356. Lateral aspect of same. 357. Dorsal aspect of same. Figs. 358-363. Right stylus of female ovipositor, ventral aspect. 358. _Brachinus fumans_ Fabricius, Kahlotus, Washington. 359. _Brachinus favicollis_ Erwin, El Sauzal, Baja California, Mexico. 360. _Brachinus puberulus_ Chaudoir, Texas. 361. _Brachinus imperialensis_ Erwin, Douglas, Arizona. 362. _Brachinus perplexus_ Dejean, Dundee, Mississippi. 363. _Brachinus velutinus_ Erwin, Davis, California. Accompanying scale lines equal 1.0 mm.

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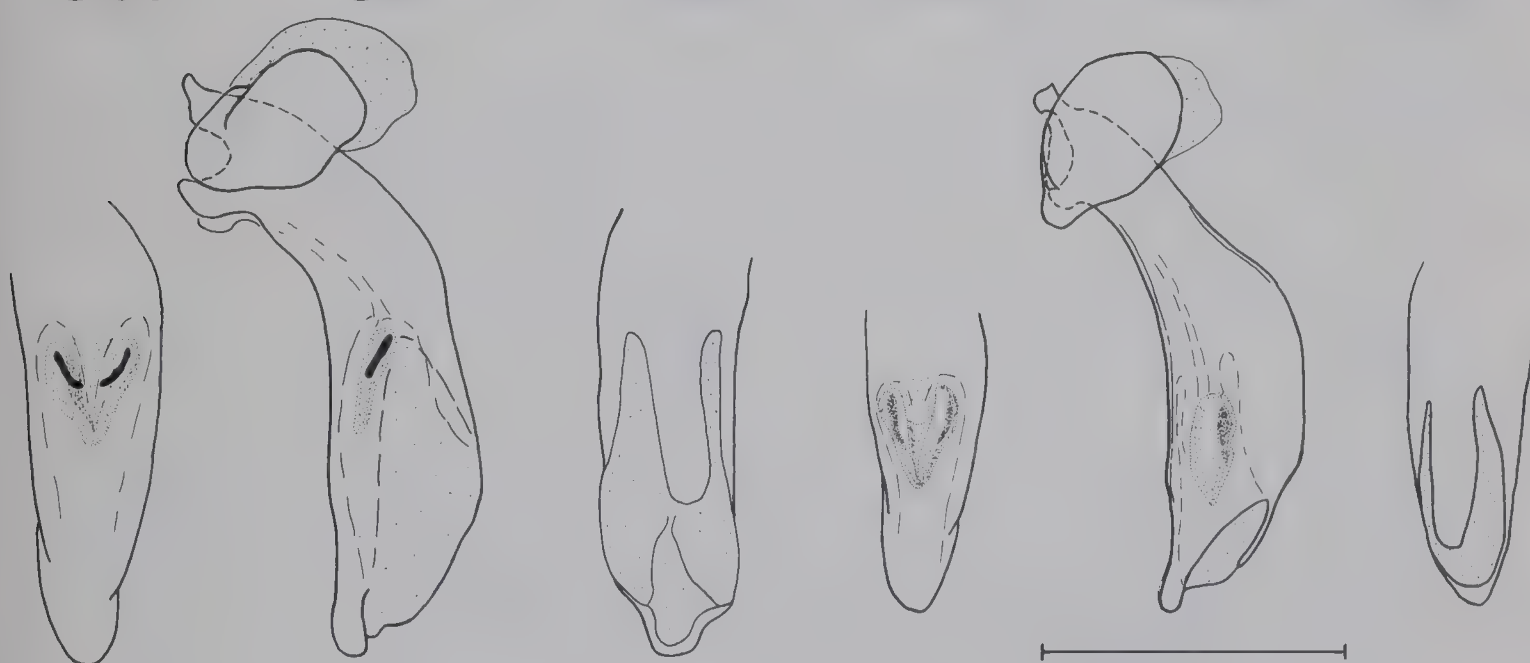

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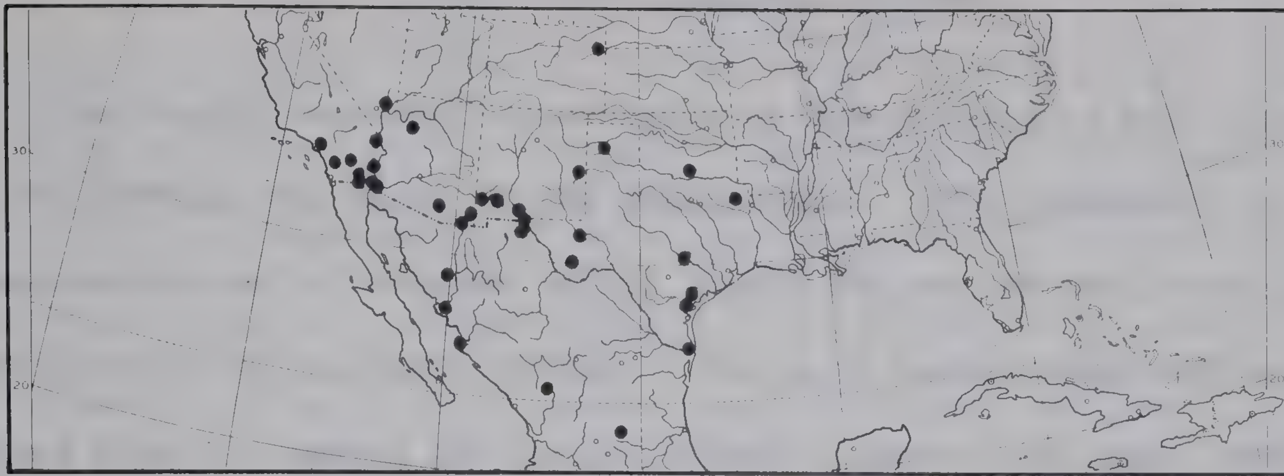
Figs. 364-369. Geographical distribution maps. 364. *Brachinus imperialensis* Erwin. 365. *Brachinus favicollis* Erwin. 366. *Brachinus perplexus* Dejean. 367. *Brachinus velutinus* Erwin. 368. *Brachinus puberulus* Chaudoir. 369. *Brachinus fumans* Fabricius.



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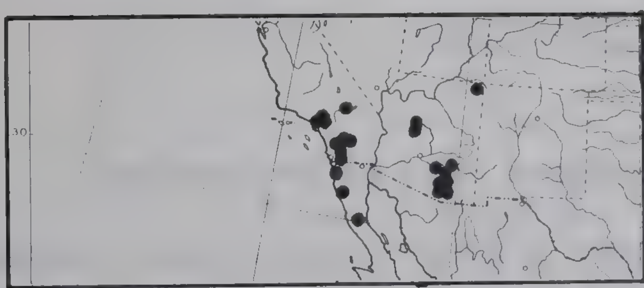

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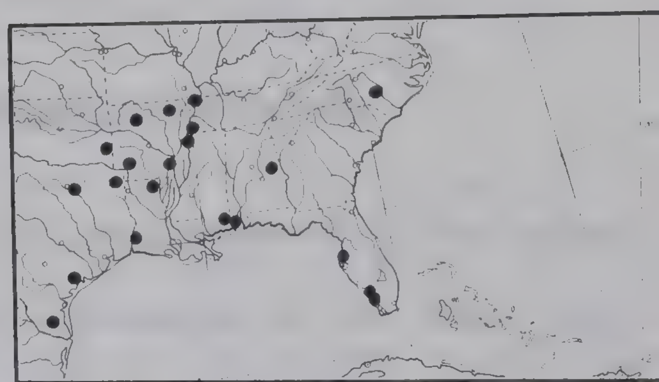

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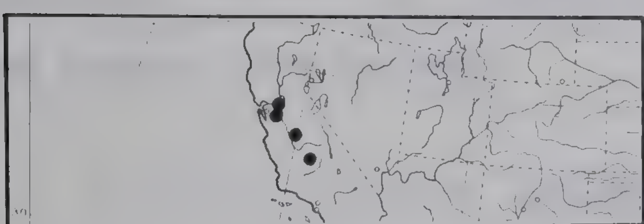

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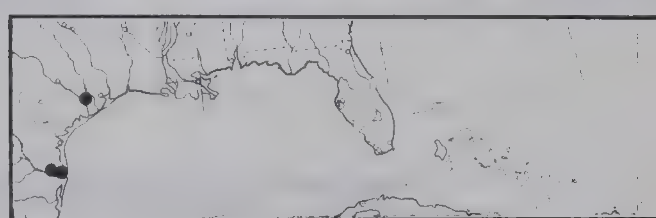

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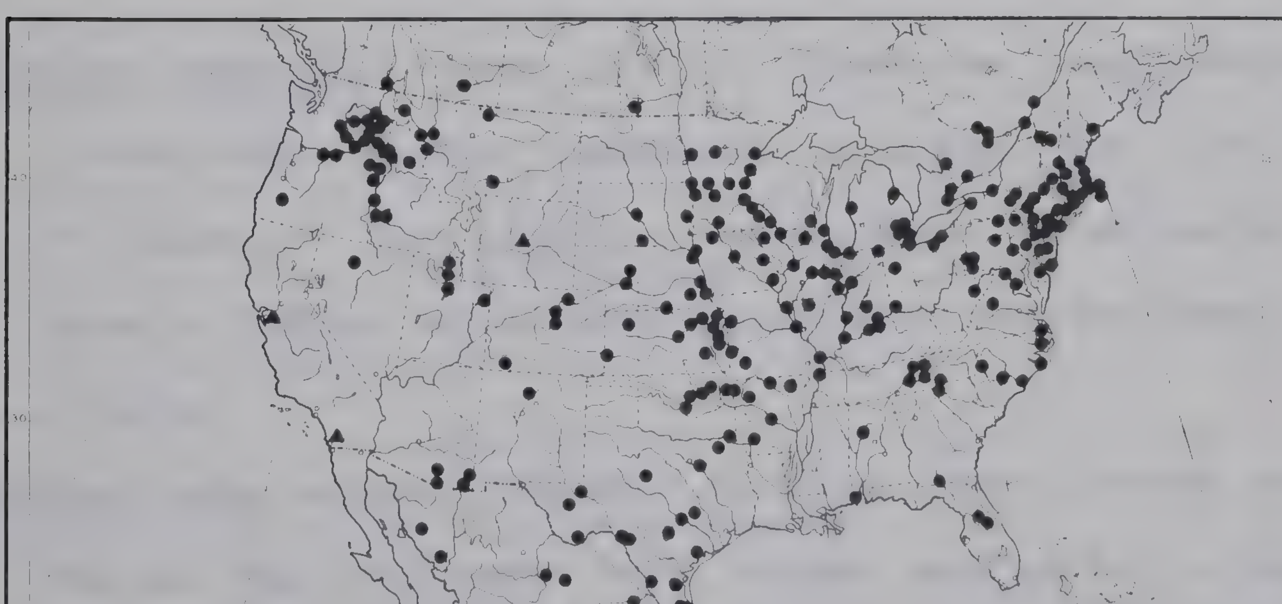

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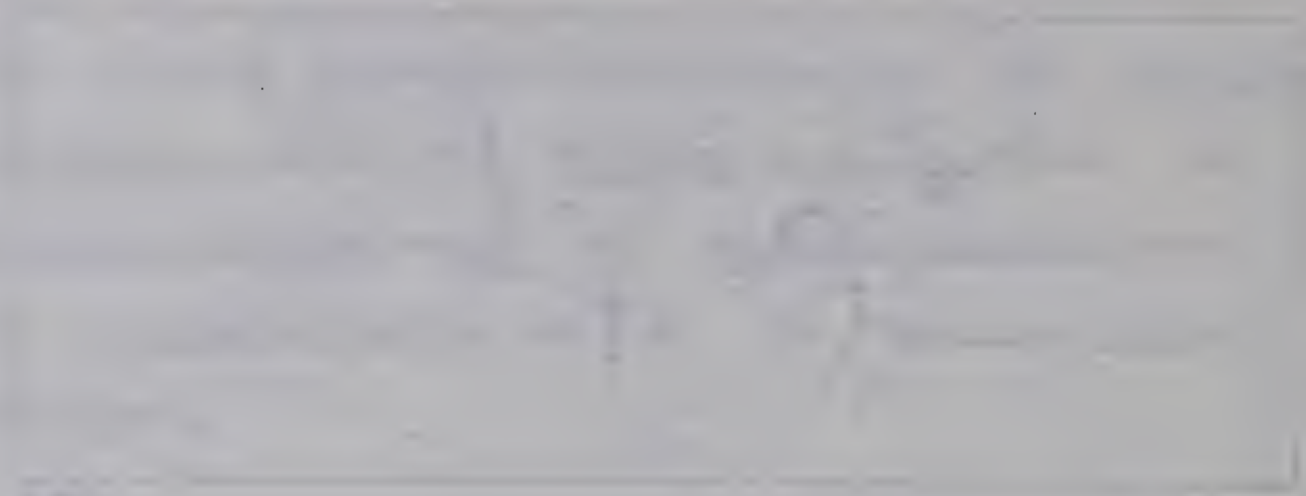
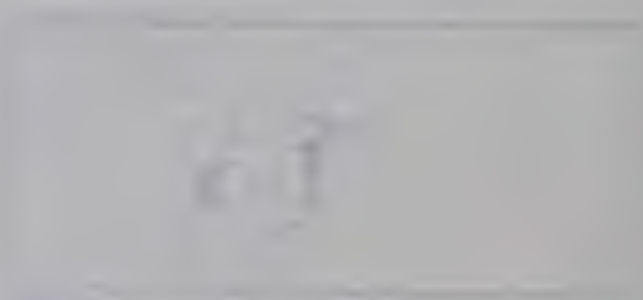
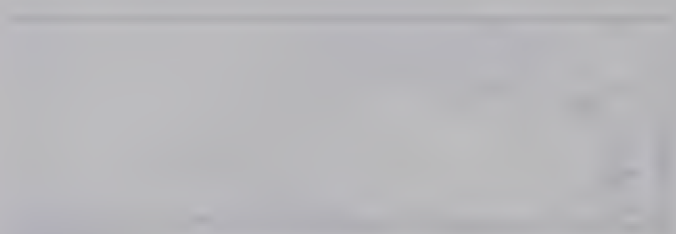
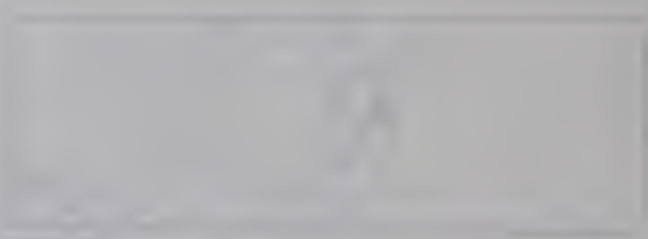








4.70 The cordicollis group

The single characteristic shared by the species of this group is the form of the virga of the endophallus. This structure is characteristically H-shaped with a dorsal fin on the midline or some modification of the basic H-shape. The more darkly pigmented areas extend from the median fin to the lateral lobes. The eight species belonging to this group are arrayed in four subgroups.

4.701 The cordicollis subgroup

The species of this subgroup are characterized by the robust median lobe, usually with a ventral depression on the shaft, and the true H-shaped virga. Four species, B. cordicollis Dejean, B. sublaevis Chaudoir, B. cyanochroaticus new species, and B. ichabodopsis new species, are included.

4.7011 Brachinus cordicollis Dejean

(Figs. 376, 377, 378, 379, 386, 391)

Brachinus cordicollis Dejean, 1826:466. Lectotype, here selected, a male, MHNP, labelled "cordicollis m. in Amer. bor." and "D. LeConte." Type locality.—North America, as originally given by Dejean, but herewith restricted to Fairfax County, Virginia.

Brachinus velox LeConte, 1848:206. Lectotype, here selected, a male, MCZ red type label number 5850, further labelled with a pink disc, "90" and "v. velox LeC." Type locality.—New York, as originally given by LeConte. LeConte, 1862:524.

Brachinus leptocerus Chaudoir, 1868:296. Lectotype, here selected, a female, MHNP, labelled "Ex Museo Chaudoir" and standing fifth in a series of six specimens behind box label "leptocerus Chaud. Etas Unis Guex." Type locality.—United States, as originally given by Chaudoir, but herewith restricted to New York. NEW SYNONYMY.

Brachynus gracilis Blatchley, 1910:160. Lectotype, previously selected (Blatchley, 1930:33), a male, PUM, labelled "Marshall Co., Ind. W. S. B. 10-14-03" "L-11/2-36" red type label, and a black bordered label "Holotype Brachynus gracilis Blatchley, 1910." Type locality.—Marshall County, Indiana, as originally given by Blatchley. NEW SYNONYMY.

Notes.—The specimen labelled gracilis holotype cannot be a holotype because Blatchley did not originally designate it so.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 7.0 to 10.2 mm.

Color. Antennal articles 3 and 4 apically, metepisterna, and abdominal sterna and terga infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and disc of pronotum rugose and punctate, punctures moderately impressed.

Head. Frontal furrows moderately impressed. Antennal scape cylindrical or almost so. Ligula with center area ellipsoid-convex with two lateral rows of three setae per row. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 379) slightly convex, flattened along center line, sides narrowly reflexed. Proepisterna pubescent throughout, proepipleura variable. Anterior tibia with anterior surface strigose.

Pterothorax. Elytra elongate, narrow, costae weakly elevated. Humeral angle square. Costae and depressions pubescent. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 376, 377, 378). Median lobe with plane of shaft rotated 45° from plane of basal bend. Basal bend long. Apex of shaft broad and blunt, with slight notch at middle. Venter of shaft with elongate longitudinal depression. Ligule elongate, narrow, rounded apically. Virga (figs. 376, 377). Female (fig. 386). Stylus narrow, parallel-sided, rounded apically.

Variation.—Besides the intrapopulational variation in the shape of the pronotum and the body size, setae of the proepipleura are present in some individuals, absent in others.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Latin, cordis = heart; collis = neck; referring to the cordiform outline of the pronotum of these beetles.

Collecting notes.—C. Chantel collected these beetles from under stones on sandy clay terraces above the Becancour River in Quebec.

Life history.—Members of this species have been collected from April to October. Teneral adults were collected in April in New York, in May in Ontario, in July in Pennsylvania, and in September in Wisconsin. Overwintering is probably in the adult stage.

Distribution.—(Fig. 391). The range of this species extends

from New Brunswick and Virginia west to Utah, Colorado, and New Mexico. I have seen 864 specimens from the following localities:

CANADA

NEW BRUNSWICK: (Saint John) UWMW. ONTARIO: (Belleville) UASM; (Erindale) CAS; (Lake Abitibi, Low Bush) CAS; (Rogue Hills) CAS; (Summerville) CAS; (Toronto) CAS; (Willowdale) CAS. QUEBEC: (Becancour) CCh; (Como) MCZ; (Perrot Isle) CMPP; (Vaudreuil) CAS.

UNITED STATES

ARKANSAS: Washington County (No locality given) UAFA. COLORADO: Boulder County (Viele Lake) CArm; Denver County (Denver) ISNH. ILLINOIS: Cook County (Chicago) WSUP, (Des Plaines) CNHM, (Willow Springs) UMAH; Kendell County (Oswego) CNHM; La Salle County (No locality given) RTBe; McHenry County (Algonquin) ISNH; Putnam County (No locality given) ISNH; County unknown (Volo) RTBe. INDIANA: CNHM, Lake County (Hessville) CMPP. IOWA: Buchanan County (Independence) MCZ; Henry County (Mount Pleasant) CAS; Howard County (Elma) AMNH; Johnson County (Iowa City) MCZ, USNM, (Solon) USNM; Story County (Ames) ISUA. KANSAS: Riley County (No locality given) KSU; Shawnee County (Topeka) KSU. MARYLAND: (No locality given) MCZ. MASSACHUSETTS: Hampden County (Chicopee) MCZ; Middlesex County (Cambridge) MCZ, (Concord) MCZ, (Sudbury) MCZ, (Wayland) MCZ. MICHIGAN: Barry County (Otis Lake) TFHl; Charlevoix County (Garden Island) UMAH; Cheboygan County (No locality given) UMAH; Gratiot County (No locality given) UMAH; Kent County (Grand Rapids) UNLN; Saint Claire County (Point Huron) USNM; Washtenaw County (Ann Arbor) UMAH, (Whitmore Lake) JSch; Wayne County (Detroit) MCZ; County unknown (Aurelius) OSUS. MINNESOTA: Clearwater County

(De Soto Lake, Itasca State Park) UMSP; Douglas County (Alexandria) PSUU; Hennepin County (No locality given) UMSP; Houston County (No locality given) UMSP; Mille Lacs County (Garrison) UMSP, (Mille Lacs Lake, near Garrison) UMSP; Olmstead County (No locality given) UMSP; Otter Tail County (Battle Lake) UMSP; Pine County (Snake River, 4.0 miles east of Pine City) UMSP; Ramsey County (No locality given) UMSP; Red Lake County (Plummer) UMSP; Washington County (No locality given) UMSP; County unknown (Vineland) UMSP. MISSOURI: (No locality given) ISNH. NEBRASKA: Dodge County (Fremont) UNLN; Lancaster County (Lincoln) UNLN; Saunders County (Ashland) UNLN. NEW JERSEY: Gloucester County (Woodbury) USNM; Hunterdon County (Hampton) AMNH; Middlesex County (New Brunswick) AMNH; Passaic County (Passaic) AMNH; Somerset County (No locality given) UMAH; Sussex County (Hopatcong) AMNH; Union County (Elizabeth) AMNH; County unknown (Snake Hill) AMNH. NEW MEXICO: Bernalillo County (Albuquerque) USNM. NEW YORK: Albany County (Altamont) CNHM, CUNY; Cayuga County (Cayuga) MCZ, (Fair Haven) LACM; Clinton County (Plattsburg) WSUP; Erie County (East Aurora) CUNY, (Hamburg) CAS; Greene County (Catskill) USNM; Jefferson County (Cape Vincent) CUNY; Monroe County (Rochester) LACM, MCZ; New York County (Bronx Park) CAS, (New York City) MCZ; Niagara County (Olcott) AUAA, CUNY; Ontario County (Fish Creek, near Victor) UASM, (Geneva) UMAH; Suffolk County (Babylon) AMNH; Schuyler County (Cayuta Lake) UASM, (Watkins Glen) AMNH, MCZ, VMKi; Tompkins County (Buttermilk Falls) PUM, (Ithaca) AUAA, CAS, CUNY, ISNH, KSU, LACM, MCZ, OUCO, UASM, UCR, UIMI, UNLN, (Ludlowville) CUNY, (Varna) UASM; Westchester County (Peekskill) MCZ; Wayne County (No locality given) UASM; County unknown (Enfield Falls) CNC,

(Taughannock Falls) CUNY. OHIO: Delaware County (No locality given) PUM; Franklin County (Columbus) OUCO, PUM; Pickaway County (No locality given) SJSC; Putnam County (Auglaize River) PUM; Ottawa County (Bass Island) PUM; Williams County (Saint Joseph River) PUM. PENNSYLVANIA: Allegheny County (Pittsburgh) CMPP, OSUS; Bradford County (Susquehanna River, Wyalusing) GRNo; Crawford County (Conneaut Lake) CMPP; Cumberland County (Camp Hill) CUNY; Dauphin County (Harrisburg) VMKi; Erie County CMPP, (Erie) CUNY; Franklin County (Chambersburg) USNM; Montgomery County (Arcola) ANSP, OUCO; Northampton County (Easton) CAS, (Water Gap) AMNH; Pike County (Milford) SDNHM; Westmoreland County (Jeannette) CMPP; County unknown (Edge Hill) USNM, (Lehigh Water Gap) USNM. UTAH: (No locality given) ISUA. VERMONT: Bennington County (No locality given) MCZ; Chittenden County (East Georgia) RTBe, (Grand Isle) MCZ. VIRGINIA: Fairfax County (Great Falls) USNM; Loudoun County (No locality given) ANSP, MCZ. WEST VIRGINIA: County unknown (Brush Creek) CUNY. WISCONSIN: Dane County (No locality given) UWMW; Green County (Brodhead) UMAH; Winnebogo (Oshkosh) CAS.

4.7012 *Brachinus* *cyanochroaticus* new species

(Figs. 375, 380, 381, 382, 387, 392)

Type locality.—Eleven miles west of York, North Dakota.

Type specimens.—The holotype male and allotype female are in MCZ. Both were collected at the type locality by G. E. Ball on May 30, 1956. Four paratypes collected at various localities and on various dates are in AMNH, CAS, MCZ, TLEr, and UASM.

Diagnostic combination.—Medium-sized beetles, 7.0 to 11.3 mm.

Color. Antennal articles 3 and 4 apically, metepisterna, metasternum at sides, and abdominal sterna and terga infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue, usually with metallic luster.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows rugose and punctate. Disc of pronotum punctate, punctures barely impressed.

Head. Frontal furrows moderately impressed. Antennal scape robust, widest at middle, otherwise head as in cordicollis.

Prothorax. As in cordicollis, except sides of pronotum (fig. 375) more widely reflexed and proepipleura glabrous.

Pterothorax. As in cordicollis.

Abdomen. As described for genus.

Genitalia. Male (figs. 380, 381, 382). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend long. Shaft as in cordicollis. Entire median lobe more robust than in cordicollis. Virga (figs. 380, 381). Female (fig. 387). Stylus as in cordicollis.

Variation.—The members of this species vary considerably in the shape of the pronotum and in the color of the elytra. These are both local variations, but generally the color has a metallic luster in the north and western portions of the range, while in the south and eastern parts of the range, the color becomes dull blue.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Greek, kyanos = blue; chroaticus = color of the skin; referring to the blue color of the elytra of these beetles.

Collecting notes.—H. Goulet collected these beetles near old

beaver houses in the company of Platypatrobus lacustris Darlington, and G. E. Ball and R. T. Bell collected them at the edges of ponds.

Life history.—Members of this species have been collected from April to October. Teneral adults were collected in May in Quebec. At least some adults overwinter.

Distribution.—(Fig. 392). The range of this species extends from British Columbia and Idaho, east to Massachusetts, and south to Kansas. I have seen 342 specimens from the following localities:

CANADA

BRITISH COLUMBIA: (Salmon Arm) CAS. MANITOBA: (Boissevain, south of Brandon) ZMLS; (Whitewater Lake) UASM, ZMLS. ONTARIO: (Belleville) CUNY; (Britannia) CAS; (Craigleith, West Collingwood, Georgian Bay) ZMLS; (De Cew Falls) CNC; (Grand Bend, Lake Huron) ZMLS; (Gravenhurst) AMNH; (Hyde Park Corner) RTBe; (Lake of the Woods, Clearwater Bay) CNC; (Point Pelee) ZMLS; (Prince Edward County) CUNY; (Toronto) CAS; (Turkey Point, Lake Erie) ZMLS. QUEBEC: (Dorval) CAS; (Gatineau, 1.0 miles southwest of Meach Lake) CNC; (Lachine) CAS; (Lac Saint Jean) CAS; (La Trappe) ZMLS; (Montreal) CAS; (Outrem't) CAS; (Rigaud) CAS, HGou; (Saint Eustache) CAS; (Saint Rose) CAS; (Venise) CCh.

UNITED STATES

COLORADO: Boulder County (Bellmire Reservoir, Longmont) CArm, (McCall Lake, Lyons) CArm; Larimer County (Fort Collins) CAS; Weld County (Greeley) USNM; Yuma County (Wray) KSU. CONNECTICUT: New Haven County (New Haven) CAS. IDAHO: Nez Perce County (Lewiston) UIMI. ILLINOIS: Cook County (Chicago) WSUP; Putnam County (No locality given) ISNH. INDIANA: Posey County (Hovey Lake) PUM.

IOWA: Clayton County (Guttenberg) ISUA; Dickinson County (Lake Okoboji) USNM; Johnson County (Iowa City) ANSP; Palo Alto County (Ruthven) UMAH; Story County (Ames) ISUA. KANSAS: (No locality given) USNM. MASSACHUSETTS: Bristol County (Dartmouth) ISUA; Hampshire County (Mount Tom) CMPP; Middlesex County (Waltham) MCZ, (Wayland) MCZ. MICHIGAN: Calamazoo County (Gull Lake Biology Station) JSch; Eaton County (Grand Ledge) USNM; Huron County (Charity Island) UMAH; Kent County (Grand Rapids) CNHM, UNLN; Missaukee County (No locality given) UMAH; Oceania County (Crystal Valley) CMHM (Silver Lake State Park) UMAH; Tuscola County (Fostoria) RCGr; Washtenaw County (Ann Arbor) ISUA, UMAH, (Whitmore Lake) JSch, UMAH; Wayne County (Detroit) CAS. MINNESOTA: Clearwater County (De Soto Lake, Itasca State Park) UMSP, (Itasca State Park) UMSP; Houston County UMSP, (Brownsville) USNM; Stearns County (Rice Lake, Paynesville) USNM; Traverse County (No locality given) UMSP. MISSOURI: Counties unknown (Cliff Caves) USNM, (Luxemburg) USNM. MONTANA: Big Horn County (Lodge Grass) MSUM. NEBRASKA: (No locality given) ISNH. NEW HAMPSHIRE: Cheshire County (Swanzey Pond) MCZ. NEW JERSEY: Essex County (Orange Mountains) USNM; Hudson County (Secaucus) CAS; Morris County (Towaco) USNM; Passaic County (Paterson) AMNH; Warren County (Phillipsburg) CAS; County unknown (Snake Hill) AMNH, CAS. NEW YORK: Cayuga County (Montezuma Marsh) UASM; Chautauqua County (Mayville) UASM; Cortland County (McLean Bogs) CUNY; Erie County (Buffalo) CAS, ISNH, (East Aurora) CUNY, (Lancaster) CAS; Genesee County UMAH, (Batavia) CUNY; Herkimer County (Warren) MCZ; Monroe County (Rochester) LACM; New York County (New York City) MCZ, (Staten Island) CNHM, USNM,

(Yonkers) CAS; Niagara County (Olcott) CUNY; Orange County (West Point) USNM; Rockland County (Piermont) CAS, SDNHM, USNM; Tompkins County (Ithaca) CAS, CUNY, UASM; Wyoming County (Pike) AMNH, MCZ; County unknown (West Hebron) USNM. NORTH DAKOTA: Benson County (11.9 miles west of York) UASM; McLean County (Turtle Mountain) UMAH; Ramsey County (Devils Lake) USNM. OHIO: Ashtabula County (Ashtabula, Chestnut Grove) PUM. PENNSYLVANIA: Allegheny County CMPP, USNM, (Pittsburgh) CMPP. SOUTH DAKOTA: Brookings County (Brookings) VMKi, (Volga) CAS. VERMONT: Chittenden County (Burlington) RTBe, (Gillette Pond, Richmond) RTBe, (Home Creek Delta, Charlotte) RTBe, (Shelburne) CAS, (Shelburne Pond, Shelburne) RTBe; Franklin County (La Moille River, East Georgia) RTBe. WISCONSIN: Dane County (Madison) UWMW; Dodge County (Beaver Dam) ROM, UMAH. WYOMING: County unknown (Pine Bluffs) AMNH.

4.7013 Brachinus sublaevis Chaudoir

(Figs. 371, 372, 373, 374, 388, 393)

Brachinus sublaevis Chaudoir, 1868:293. Lectotype, here selected, a female, MHNP, labelled "ant maculat abdomn. gra" and "Ex Museo Chaudoir." Type locality.—Florida, here designated.

Brachynus pulchellus Blatchley, 1910:161. Lectotype, a female, PUM, labelled "Posey Co. Ind. WSB" "4-18-07" "Purdue Blatchley Coll." and with a red type label. Type locality.—Posey County, Indiana, as originally given by Blatchley. NEW SYNONYMY.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium to large-sized beetles, 9.6 to 11.7 mm.

Color. Antennal articles 3 and 4, metepisterna, metasternum at sides, and abdominal sterna and terga infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra dull blue.

Microsculpture. As described for genus.

Macrosculpture. As in cordicollis.

Head. As in cordicollis, except ligula with only two apical setae.

Prothorax. As in cordicollis, except proepipleura glabrous and proepisterna pubescent both anteriorly and posteriorly, but glabrous medially.

Pterothorax. Elytra elongate, narrow, costae absent or almost so. Humeral angle square to projecting. Elytra densely pubescent. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 371, 372, 373). Median lobe with plane of shaft rotated slightly from plane of basal bend. Basal bend long. Apex of shaft blunt, venter of shaft concave at middle. Ligule long, narrow, truncate apically. Virga (figs. 371, 372). Female (fig. 388). Stylus short, narrow, rounded apically.

Variation.—The shape of the pronotum, body size and the height of the costae varies within population samples.

Flight.—These beetles have been collected at lights repeatedly throughout the range of the species.

Etymology.—Latin, laevis = smooth; sub = somewhat; referring to the barely-elevated costae of the elytra of these beetles.

Collecting notes.—My wife and I collected these beetles in Scirpus-Typha marshes in Florida and in the Okefenokee Swamp.

The beetles were below water line in the rhizomes of grass clumps (along with members of 36 other species of Carabidae, in the Okefenokee).

Life history.—Members of this species have been collected from January to August, but no teneral adults were seen.

Distribution.—(Fig. 393). The range of this species extends from Florida north to Michigan, and west to western Texas. I have seen 234 specimens from the following localities:

UNITED STATES

ALABAMA: Mobile County (Magazine Point) CAS, (Mobile) CAS, USNM, (Saraland) CAS, (Whistler) ANSP; Tallapoosa County (Alexander City) AUAA. ARKANSAS: Washington County (No locality given) UAFA. FLORIDA: Alachua County (Gainesville) FDAG, USNM; Collier County (Everglades) UONO; Dade County (Long Pine Key) CUNY, (Paradise Key) USNM; Duval County (Jacksonville) CAS; Hernando County (Brooksville) CNHM; Highlands County (Archbold Biology Station) CUNY, PSUU, (Avon Park) FDAG, (Highlands Hammock State Park) TLEr, UASM; Hillsborough County (Hillsborough River State Park) UMAH, (Plant City) UMAH, (Tampa) CUNY; Lake County (Fruitland Park) UMAH; Lee County (Fort Myers) CUNY; Levy County (Manatee Springs State Park) RFre; Manatee County (Oneco) UASM; Marion County MCZ, (Juniper Springs) TLEr; Pinellas County (Dunedin) CAS, PUM; Seminole County (Sanford) PUM; Charlotte County (Bermont) UASM; Taylor County (Salem) UCD. GEORGIA: Charlton County (Okefenokee Swamp) TLEr; Lowndes County (No locality given) OUCO. INDIANA: Posey County (Hovey Lake) CEWh, (Mount Vernon) CEWh. KENTUCKY: Edmonson County (Mammoth Cave National Park) TCBa. LOUISIANA: Ouachita Parish (Calhoun) UAFA.

MICHIGAN: Lapeer County (Lapeer State Game Area) RCGr. MISSISSIPPI: George County (Lucedale) CUNY; Harrison County (10.0 miles north of Biloxi) UCD. MISSOURI: Callaway County (Readsville) MCZ. OKLAHOMA: Rogers County (Catoosa) CAS. SOUTH CAROLINA: Horry County (Myrtle Beach) VMKi. TENNESSEE: Overton County (Cleeks Mill) TCBa; Shelby County (Memphis) ANSP, CAS, UMAH. TEXAS: Hardin County (9.0 miles west of Beaumont) OSUC; Reeves County (Balmorhea Lake) UASM; Victoria County (Victoria) USNM.

4.7014 Brachinus ichabodopsis new species

(Figs. 370, 383, 384_1, 384_2, 385, 390)

Type locality.—Saint John's River, Hardkinsville, Florida.

Type locality.—The holotype male and allotype female are in MCZ The holotype was collected at the type locality by G. A. Athen (no date of collection given on label). The allotype is labelled "Fla." and "F. C. Bowditch Coll."

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Large-sized beetles, 11.1 to 16.0 mm.

Color. Antennal articles 3 and 4, mesepisterna, mesepimera, metepisterna, metasternum at sides, and abdominal sterna and terga infuscated to black, otherwise ferrugineous. Dorsal surface and epipleura of elytra dull blue-black.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows rugose and punctate. Disc of pronotum rugose along midline and punctate, punctures barely impressed.

Head. Frontal furrows moderately impressed. Antennal scape

robust, widest apically, article 3 elongate, longer than diameter of eye. Ligula with center area ellipsoid-convex with two apical setae. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 370) slightly convex, elongate and narrow, concave along center line, sides slightly reflexed. Proepipleura glabrous. Proepisterna pubescent anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior margin strigose.

Pterothorax. Elytra very elongate, narrow, weakly costate. Pubescence mostly confined to depressions on disc. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 383, 384_1, 384_2). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend long. Apex of shaft blunt and broad. Ligule long, widening apically. Virga (figs. 383, 384_1). Female (fig. 385). Stylus very broad, parallel—sided, broadly rounded apically.

Variation.—Too few specimens are known to evaluate geographic variation.

Flight.—The flight of these beetles has not been recorded.

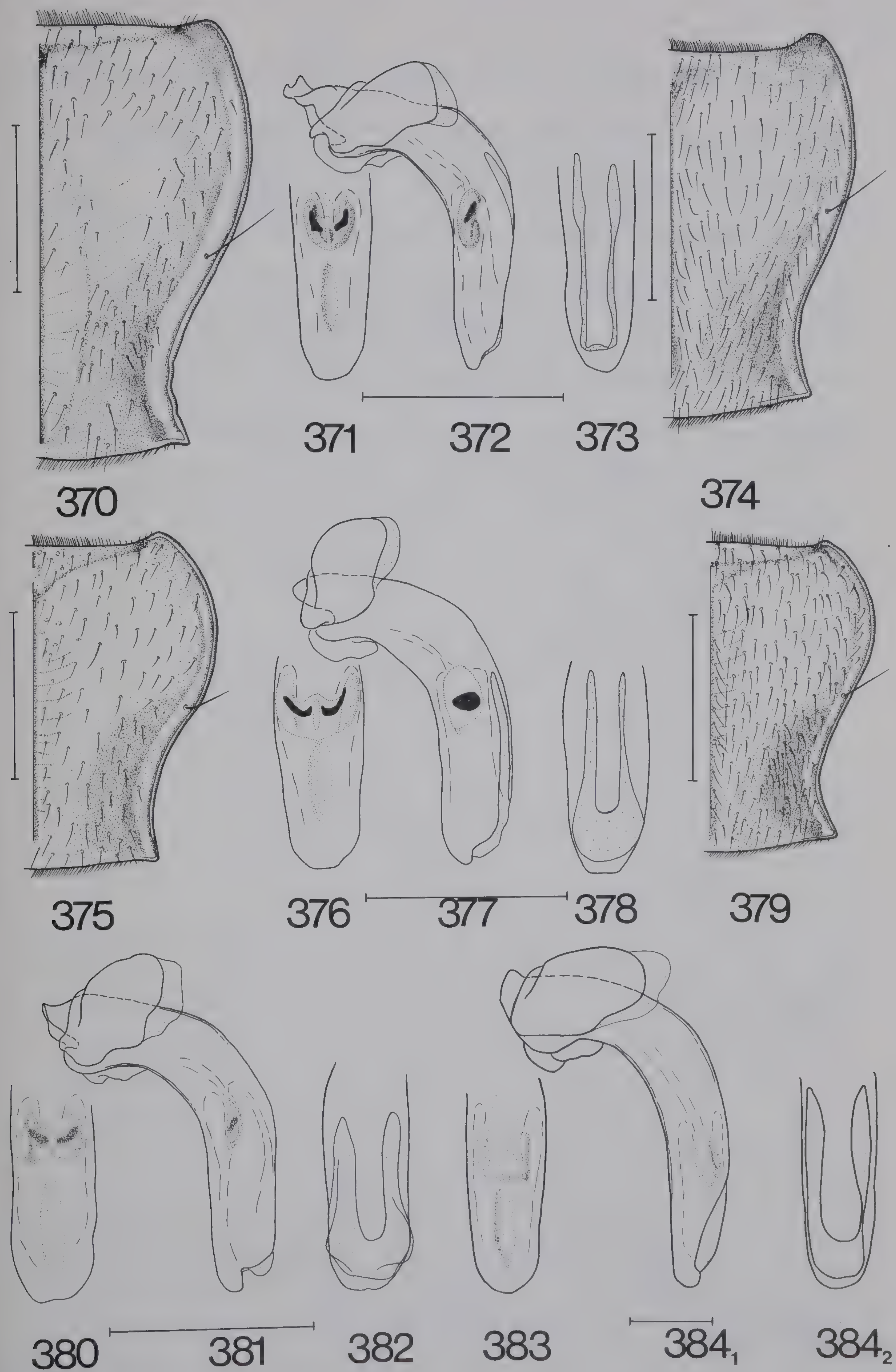
Etymology.—From English, Ichabod Crane, Washington Irving's long-legged character in the Legend of Sleepy Hollow; Latin, opsis = likeness; referring to the elongate, long-legged habitus of these beetles.

Distribution.—(Fig. 390). I have seen only the two specimens designated as types, they are from the following locality:

UNITED STATES

FLORIDA: County unknown (Hardkinsville, Saint John's River) MCZ.

Figs. 370, 374, 375, 379. Pronotum, right half, dorsal aspect. 370. *Brachinus ichabodopsis* new species, Hardkinsville, Florida. 374. *Brachinus sublaevis* Chaudoir, Archbold Biology Station, Florida. 375. *Brachinus cyanochroaticus* new species, 11.9 miles west of York, North Dakota. 379. *Brachinus cordicollis* Dejean, Toronto, Canada. Figs. 371-373, 376-378, 380-385. Male genitalia. 371. *Brachinus sublaevis* Chaudoir, Archbold Biology Station, Florida, ventral aspect. 372. Lateral aspect of same. 373. Dorsal aspect of same. 376. *Brachinus cordicollis* Dejean, Ithaca, New York, ventral aspect. 377. Lateral aspect of same. 378. Dorsal aspect of same. 380. *Brachinus cyanochroaticus* new species, 11.9 miles west of York, North Dakota, ventral aspect. 381. Lateral aspect of same. 382. Dorsal aspect of same. 383. *Brachinus ichabodopsis* new species, Hardkinsville, Florida, ventral aspect. 384_1. Lateral aspect of same. 384_2. Dorsal aspect of same. Accompanying scale lines equal 1.0 mm.



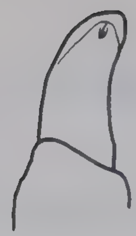
370 371 372 373 374

375 376 377 378 379

380 381 382 383 384_1 384_2

Figs. 385-388. Right stylus of female ovipositor, ventral aspect. 385. *Brachinus ichabodopsis* new species, Florida. 386. *Brachinus cordicollis* Dejean, Toronto, Canada. 387. *Brachinus cyanochroaticus* new species, 11.9 miles west of York, North Dakota. 388. *Brachinus sublaevis* Chaudoir, Highlands Hammock State Park, Florida. Figs. 390-393. Geographical distribution maps. 390. *Brachinus ichabodopsis* new species. 391. *Brachinus cordicollis* Dejean. 392. *Brachinus cyanochroaticus* new species. 393. *Brachinus sublaevis* Chaudoir. Accompanying scale line equals 1.0 mm.

385



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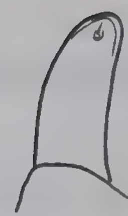

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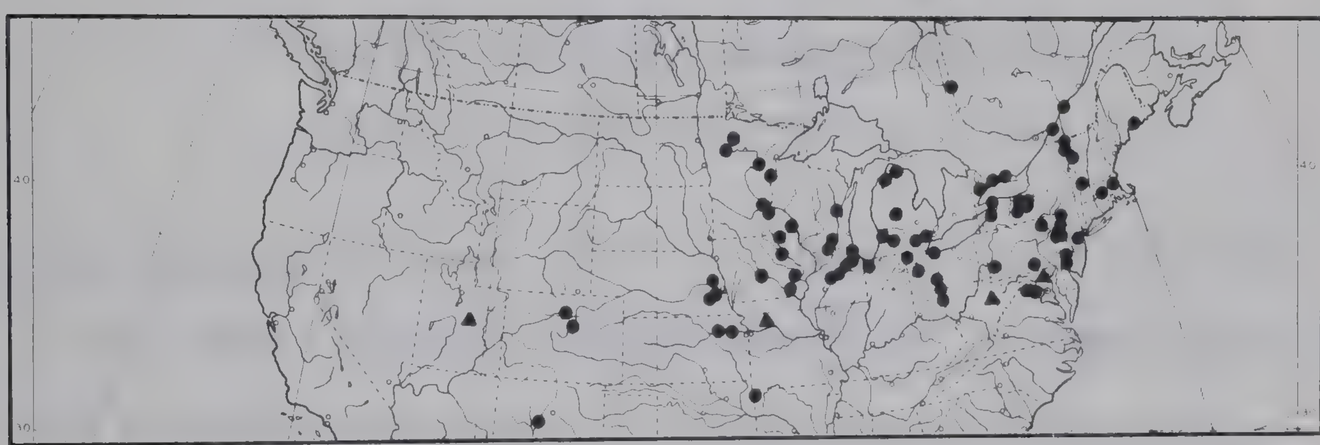

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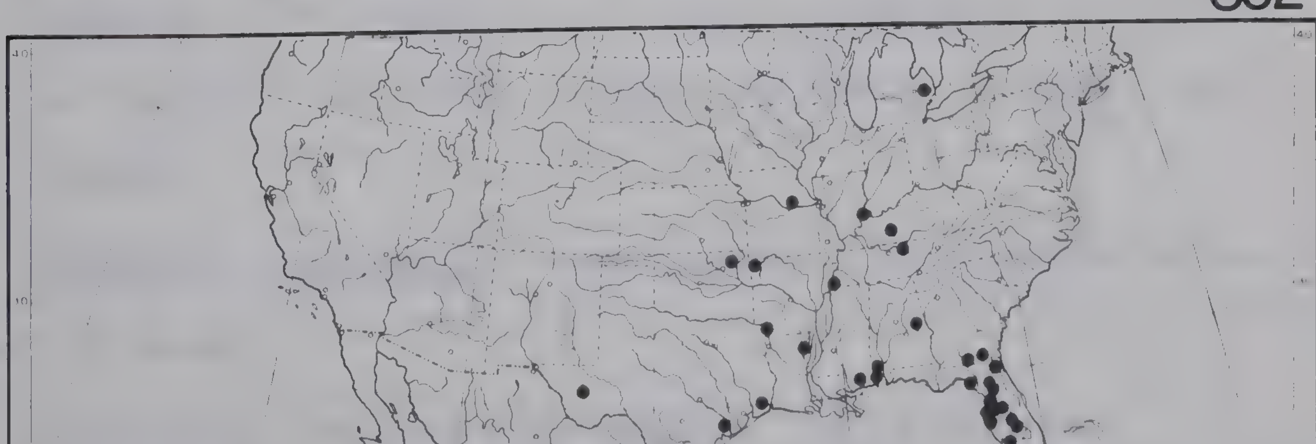


393

4.702 The *oxygonus* subgroup

The species of this subgroup are similar in form of the median lobe and modification of the virga. Although the virga is not truly H-shaped, it has the dorsal fin and similar cross-brace structure. Also the beetles externally are characteristic in habitus with those of the *cordicollis* subgroup. Three species, *B. oxygonus* Chaudoir, *B. vulcanoides* new species, and *B. fulminatus* new species, are included here.

4.7021 *Brachinus oxygonus* Chaudoir
(Figs. 395, 398, 399, 400, 412, 416)

Brachinus oxygonus Chaudoir, 1843:714. Lectotype, here selected, a male, MHNP, labelled "oxygonus Chaud" and "Ex Museo Chaudoir." The specimen stands first in a series above the box label "stygicornis Say." *Type locality*.—North America, as originally given by Chaudoir, but herewith restricted to Highlands County, Florida.

Brachinus stenomus Chaudoir, 1868:291. Lectotype, here selected, a male, MHNP, labelled "Guex" and "Ex Museo Chaudoir." *Type locality*.—North America, as originally given by Chaudoir, but herewith restricted to Highlands County, Florida. NEW SYNONYMY.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 7.4 to 10.0 mm.

Color. Antennal articles 3 and 4, metepisterna, metasternum at sides, and abdominal sterna and terga infuscated to black, otherwise

ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows shallowly rugose. Surface of pronotum with scattered, shallowly impressed setiferous punctures.

Head. Frontal furrows moderately impressed. Antennal scape cylindrical, or almost so. Ligula with center area ellipsoid-convex with two apical setae. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 395) slightly convex, flattened along center line, sides slightly reflexed. Proepipleura glabrous, proepisterna with a few setae both anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior surface strongly strigose.

Pterothorax. Elytra elongate, narrow, weakly costate. Humeral angles square. Costae and depressions pubescent. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 398, 399, 400). Median lobe with plane of shaft rotated 45° from plane of basal bend. Basal bend long. Shaft narrow, not robust. Apex of shaft blunt, slightly notched at middle. Ligule elongate, paralleliform. Virga (figs. 398, 399). Female (fig. 412). Stylus broad basally, tapered gradually to broadly rounded apex.

Variation.—Intrapopulational variation occurs in the amount of infuscation on antennal articles 3 and 4 and the metasternum, in the shape of the pronotum and body size, and in the number of setae on the proepisterna.

Flight.—These beetles have been collected repeatedly at lights in Florida.

Etymology.—Greek, oxys = sour, acid; gonus = product; referring to the chemical released by crepitation of these beetles.

Life history.—Members of this species have been collected from January to July, but no teneral adults were seen.

Distribution.—(Fig. 416). The range of this species extends from the Florida keys, north to Missouri, and North Carolina, and west to Texas. I have seen 137 specimens from the following localities:

UNITED STATES

ALABAMA: Mobile County (Magazine Point) CAS, (Mobile) ANSP, CAS, USNM; Tallapoosa County (Smith Mountain Tower) AUAA. FLORIDA: Alachua County (Gainesville) CNC, FDAD, TLEr, (Newnans Lake, 5.0 miles east of Gainesville) RFre, UASM; Brevard County (Cocoa) CNC, (Indian River) CAS; Collier County (Collier Seminole State Park) TLEr; Columbia County (Lake City) DRWh; Dade County (Biscayne Bay) AMNH, MCZ, (Homestead) CNC, TLEr, (Matheson Hammock) CNC, (Paradise Key) USNM, (Royal Palm State Park) PUM; Flagler County (Pellicer Creek, 13.0 miles north of Bunnell) CMPP; Hernando County (Brooksville) CNHM; Highlands County (Archbold Biology Station) CEWh, CUNY, PSUU, (Highlands Hammock State Park) TLEr, (Lake Placid) CUNY; Lake County (5.6 miles east of Juniper Springs) TLEr; Lee County (Fort Myers) AMNH; Marion County MCZ, (3.0 miles southwest of Lake Marion) CNC; Monroe County USNM, (Everglades National Park) FDAG; Orange County (Winter Park) FDAG, MCZ; Saint Lucie County (Fort Pierce) VMKi; Seminole County (Sanford) CAS; Volusia County (Enterprise) CAS; County unknown (Saint Nicholas) USNM. GEORGIA: Charlton County (Okefenokee Swamp) TLEr, USNM; Lowndes County (No locality given)

OUCO; Ware County (Waycross) UWSW. MISSOURI: Callaway County (Readsville) MCZ. NORTH CAROLINA: MCZ, Wake County (Raleigh) CNC. SOUTH CAROLINA: Florence County (Florence) VMKi.

4.7022 Brachinus fulminatus new species

(Figs. 396, 407, 408, 409, 411, 414)

Type locality.—Wayland, Middlesex County, Massachusetts.

Type specimens.—The holotype male and allotype female are in MCZ. Both specimens were collected at the type locality by C. E. White on April 15, 1930. Four paratypes collected on various dates and at various localities are in AMNH, CAS, MCZ, TLEr, and UASM

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 7.2 to 10.6 mm

Color. As in oxygonus.

Microsculpture. As described for genus.

Macrosculpture. As in oxygonus.

Head. As in oxygonus, except antennal scape robust, widest at middle, and ligula with center area with two rows of three setae each on ellipsoid-convex area.

Prothorax. As in oxygonus. Pronotum (fig. 396).

Pterothorax. As in oxygonus.

Abdomen. As described for genus.

Genitalia. Male (figs. 407, 408, 409). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend long. Apex of shaft as in cordicollis. Virga (figs. 407, 408). Female

(fig. 411). Stylus broad, tapering to acute apex.

Variation.—Besides the intrapopulational variation in total size and the shape of the pronotum, the North Carolina specimens have a more elongate and narrow pronotum.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Latin, *fulminatus* = exploding with sudden violence; referring to the crepitating behavior of these beetles.

Collecting notes.—These beetles have been collected in the *Sphagum* bogs of the Great Swamp of Rhode Island.

Life history.—Members of this species have been collected from April to November. One teneral adult was collected in April in Indiana.

Distribution.—(Fig. 414). The range of this species is discontinuous. The western most part is within the state of Indiana; the eastern most part extends from New York to Massachusetts, south to Maryland; and the southern part is within North Carolina. I have seen 139 specimens from the following localities:

UNITED STATES

CONNECTICUT: New Haven County (New Haven) CUNY. DELAWARE: Kent County (Bombay Hook) PSUU. INDIANA: Knox County (No locality given) CAS; Lake County (Miller) CAS; Marion County (No locality given) PUM; Posey County (No locality given) PUM; Spencer County (No locality given) PUM; Vigo County (No locality given) PUM. MARYLAND: Harford County (Edgewood) CUNY. MASSACHUSETTS: Bristol County (Swansea) CAS; Middlesex County (Arlington) MCZ, (Concord) MCZ, (Newton) MCZ, (Tyngsboro) CAS, (Wayland) MCZ; Norfolk County (Brookline) MCZ; Suffolk County (Dorchester) MCZ; Counties unknown

(Forest Hills) USNM, (Montgomery) MCZ. NEW JERSEY: Bergen County (Fort Lee) CAS, (Ramsey) AMNH; Burlington County (Atsion) CAS; Essex County (Caldwell) CNHM; Mercer County (Trenton) CAS; Morris County (Butler) USNM, (Towaco) USNM; Passaic County (Greenwood Lake) USNM. NEW YORK: New York County (Brooklyn) USNM, (New York City) CAS, (Yonkers) CAS, CNHM; Suffolk County (Montauk) CNHM; Wayne County (Sodus Bay) UASM; Westchester County (Peekskill) MCZ; Counties unknown (Fleetwood) CAS, (Long Island) USNM. NORTH CAROLINA: Columbus County (Whiteville) UNCR; Robeson County (Boardman) USNM; County unknown (Beauford) MCZ. PENNSYLVANIA: Allegheny County (Pittsburgh) CMPP; Dauphine County (Harrisburg) CUNY. RHODE ISLAND: Kent County (Warwick) UMAH; Washington County (Great Swamp, South Kingston) RCGr, (Watch Hill) USNM.

4.7023 *Brachinus vulcanoides* new species

(Figs. 394, 404, 405, 406, 410, 415)

Type locality.—Baychester, New York.

Type specimens.—The holotype male and allotype female are in MCZ. Both were collected by H. B. Leech on May 8, 1926. Four paratypes collected on various dates and at various localities have been deposited at AMNH, CAS, MCZ, TLEr, and UASM.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 8.6 to 10.2 mm.

Color. As in *oxygonus*.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and disc of pronotum rugose

and punctate, punctures moderately impressed.

Head. As in cordicollis, except antennal scape robust, widest at middle.

Prothorax. As in oxygonus, except pronotum (fig. 394) with sides more widely reflexed and anterior tibia with anterior surface punctate, punctures small.

Pterothorax. As in oxygonus, except pubescence more confined to depressions.

Abdomen. As described for genus.

Genitalia. Male (figs. 404, 405, 406). Median lobe with plane of shaft rotated slightly from plane of basal bend. Basal bend long. Apex of shaft as in cordicollis. Virga (figs. 404, 405). Female (fig. 410). Stylus broad, parallel-sided, rounded at apex.

Variation.—Intrapopulational variation occurs in total size, shape of pronotum, and color of the antennal articles 3 and 4 which may be totally infuscated or only have the apical third infuscated.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Latin, Vulcanus = God of Fire; oides = likeness; referring symbolically to the crepitating habit of these beetles.

Life history.—Members of this species were collected from March to November (excluding June), but no tenerals were seen.

Distribution.—(Fig. 415). The range of this species extends from Massachusetts along the coast to New Jersey. One specimen (Crescent City, Florida) may be mislabelled. I have seen 110 specimens from the following localities:

UNITED STATES

FLORIDA: Putnam County (Crescent City) USNM. MASSACHUSETTS:

Barnstable County (Barnstable) MCZ; Hampshire County (South Amherst) MCZ; Middlesex County (Arlington) ZMLS, (Concord) MCZ; Norfolk County (Dover) MCZ; (Milton) MCZ, (Quincy) MCZ; Plymouth County (Marion) MCZ, ZMLS . NEW JERSEY: Cape May County (Five Mile Beach) OUCO, (Ocean City) CAS; Ocean County (Surf City) USNM; Sussex County (Hopatcong) AMNH. NEW YORK: Nassau County (Jones Beach State Park) CAS, (Long Beach) CAS; New York County (Baychester) CAS, CNHM, MCZ, (Brooklyn) USNM, (New Lots) MCZ, (Pelham Bay Park) CNHM, (Rockaway Beach) CAS, ROM, USNM; Queens County (Flushing) AMNH; Suffolk County (Montauk) CNHM, (Quoque) CAS, (Wyandanch) USNM; Counties unknown (Aqueduct) ANSP, (Long Island) AMNH.

4.703 The *janthinipennis* subgroup

The species of this subgroup are characterized by their small, narrow, apically acute median lobe and modified H-shaped virga. The virga has a more apically extended cross-brace of the "H," thus the lower legs of the "H" appear to be missing. One species, *B. janthinipennis* (Dejean), is included.

4.7031 *Brachinus janthinipennis* (Dejean)

(Figs. 397, 401, 402, 403, 413, 417)

Aptinus janthinipennis Dejean, 1831:412. Lectotype, here selected, a female, MHNP, labelled "Aptinus" "janthinipennis m. in Amer. bor." "LeConte" and "Ex Museo Chaudoir." *Type locality*.—North America, as originally given by Dejean, but herewith restricted to New York.

Brachinus pumilio LeConte, 1848:208. Lectotype, here selected, a

male, MCZ red type label number 5841, further labelled with a pink disc and "94." Type locality.--Middle States, as given by LeConte's pink disc. NEW SYNONYMY.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Small-sized beetles, 5.7 to 8.9 mm.

Color. Ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows and disc of pronotum as in cordicollis.

Head. Frontal furrows moderately impressed. Antennal scape robust, widest at middle. Ligula with center area ellipsoid-convex with two apical setae. Mentum and submentum as in cordicollis.

Prothorax. Pronotum (fig. 397) more convex than in cordicollis, sides less reflexed. Proepipleura glabrous. Proepisterna with a few setae both anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior edge strigose.

Pterothorax. Elytra short, widest at apical third, humeral angle narrow, square or sloped. Costae weakly elevated. Elytra covered by pubescence.

Abdomen. As described for genus.

Genitalia. Male (figs. 401, 402, 403). Median lobe with plane of shaft slightly rotated from plane of basal bend. Basal bend short. Apex of shaft narrow, acute, and flattened dorso-ventrally. Ligule elongate, broad, rounded apically. Virga (figs. 401, 402). Female (fig. 413). Stylus narrow, parallel-sided, rounded apically.

Variation.—Intrapopulational variation was noted in the shape of the pronotum, body size, and the length of wings. All observed specimens have a reflexed apex, but the length outside the stigma varies locally.

Flight.—The flight of these beetles has not been recorded, and it is doubtful that they can fly.

Etymology.—Greek, *ianthinos* = violet-blue; Latin, *pennis* = wing; referring to the blue elytra of these beetles which may appear violet in certain lighting.

Collecting notes.—D. H. Kavanaugh and C. Armin collected these beetles from under stones at the edges of lakes and streams in Colorado, and T. Hlavac collected specimens on mud lake shores in Michigan.

Life history.—Members of this species have been collected from April to October. Teneral adults were collected in May, July, August, and September in Michigan, in May and September in Toronto, in May in New York, in August in Massachusetts, in September in Connecticut, and in October in Colorado. Overwintering probably takes place in the adult stage.

Distribution.—(Fig. 417). The range of this species extends from Colorado to the New England coast, and from the Great Lakes region to Texas. The Edmonton, Alberta record is highly doubtful. I have seen 1,065 specimens from the following localities:

CANADA

ALBERTA: (Edmonton) CNHM. ONTARIO: (Belleville) CNC; (Cedarvale) RTBe; (De Cew Falls) CNC; (Fanshawe Lake, near London) UASM; (London) CNHM; (Long Point) HGou; (Point Pelee) CAS, CNC; (Stag Island) UMAH;

(Toronto) CAS, CUNY, ROM, RTBe, UMAH, USNM, UWMW; (Trenton) CNC; (Willowdale) CAS, RTBe. QUEBEC: (Bécancour) CCha; (Berthierville) ZMLS; (Saint Jean) CAS.

UNITED STATES

COLORADO: Boulder County (Baseline Lake) CArm, (Boulder) CArm, (El Dorado Springs) CArm, (Four Mile Creek) CArm, (Lyons) CArm, (McCall Lake) CArm, (Saint Vrain Creek) CArm, RCGr, (Teller Lake) CArm; Denver County (Denver) USNM; Jefferson County (Bear Creek, 2.0 miles east of Morrison) DHKa; Yuma County (Wray) KSU. CONNECTICUT: Litchfield County (Cornwall) CAS, CUNY, MCZ, ZMLS. ILLINOIS: Champaign County (Urbana) CMPP; Cook County (No locality given) CNHM; Lake County (Waukegan) USNM; Union County (Wolf Lake) CNHM; County unknown (Powerton) ISNH. INDIANA: Elkhart County (Elkhart) MCZ; Fulton County (No locality given) PUM; Knox County (No locality given) CNHM; Kosciusko County CAS, PUM, (Winona Lake) UMAH; Lake County (No locality given) PUM; Marion County (Indianapolis) CEWh; Marshall County (No locality given) PUM; Starke County (No locality given) PUM; Whitley County (No locality given) PUM. IOWA: Dickinson County (Lake Okoboji) USNM; Story County (Ames) ISUA. KANSAS: Barton County (Arkansas River, Great Bend) RCGr; Reno County (No locality given) CAS; Sheridan County (State Lake, near Studley) RFre, UASM. MARYLAND: Calvert County (Port Republic) UWSW. MASSACHUSETTS: Bristol County (Fall River) CAS, MCZ; Essex County (Manchester) MCZ; Franklin County (Northfield) MCZ; Hampden County (Chicopee) MCZ, (Longmeadow) MCZ, (Wilbraham) MCZ; Hampshire County (Amherst) CEWh; Middlesex County (Woburn) MCZ; Norfolk County (Brookline) MCZ, (Wellesley) MCZ; County unknown (Egremont) MCZ.

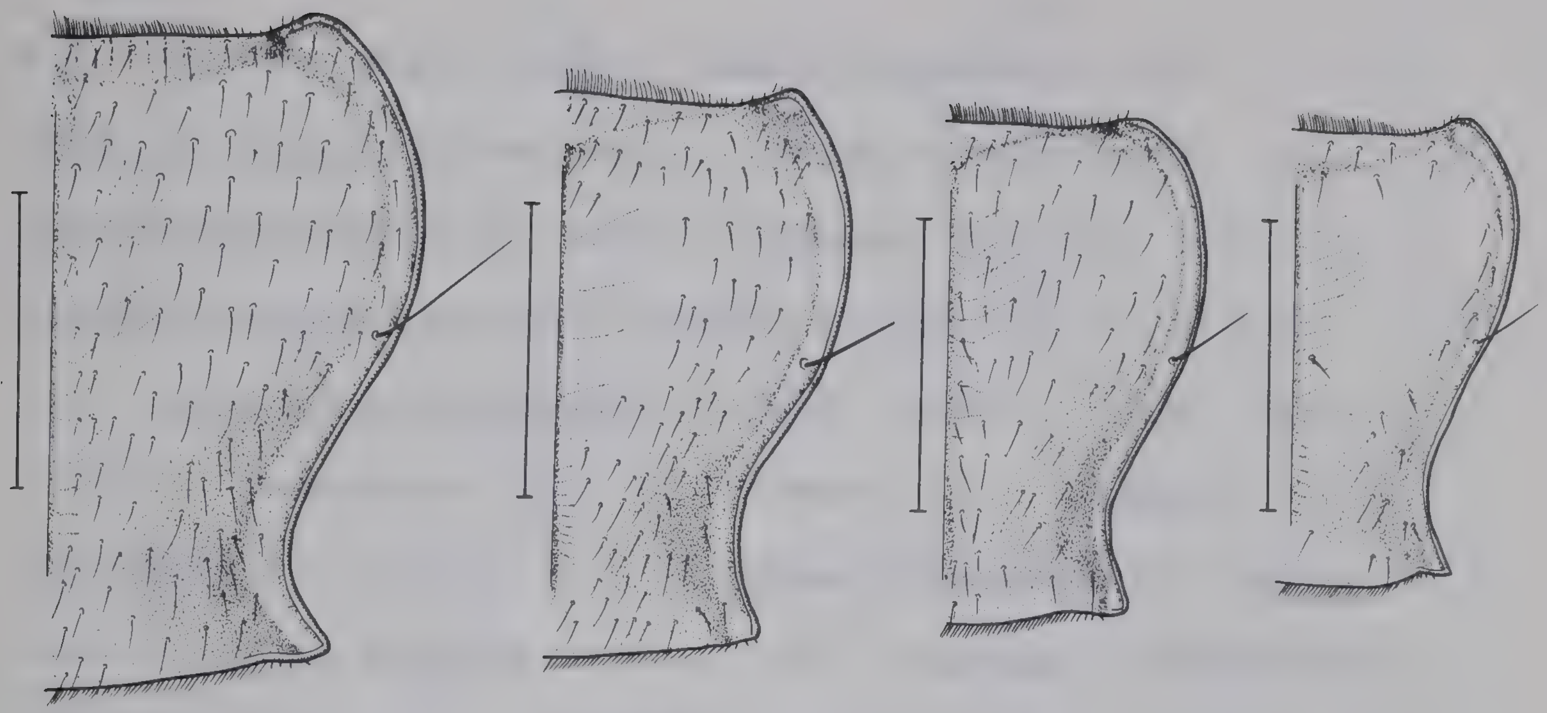
MICHIGAN: Allegan County (Douglas Lake) FDAG, KSU, OUCO, (Saugatuck) RCGr, TFHl; Alpena County UMAH, (Alpena) ISNH, USNM; Bay County (Bay City State Park) ISNH, (Pinconning) UWSW; Barry County (Otis Lake) TFHl, (Wall Lake) TFHl; Charlevoix County (Beaver Island) UMAH, (Garden Island) UMAH; Cheboygan County (No locality given) UMAH, UWMW; Clinton County (Park Lake) TFHl; Grand Traverse County (Interlochen) UMAH, (Lighthouse Beach) RCGr, (Marion Island) UMAH; Huron County (3.0 miles north of Bayport) MCZ, (Charity Island) JSch, UMAH, (Sand Point) MCZ, UMAH; Jackson County (Portage Lake) UMAH; Kent County (Grand Rapids) CNHM, UNLN, Lake County (Loon Lake) UMAH; Leelanau County (No locality given) UMAH; Mackinac County (Bois Blanc Island) UMAH, (Bois Blanc Island, Point aux Pins) UWSW, (Bois Blanc Island, Snake Islet) UWSW, (Horseshoe Bay) AMNH, (Naubinway) UASM, (Saint Martin Island) UMAH, (near Saint Ignace) CAS, UASM; Marquette County (Huron Mountains) UMAH; Oakland County UMAH (Holly) PSUU, Oceana County (Crystal Valley) CNHM; Ottawa County (No locality given) KSU; Saint Clair County (Flats Canal) UMAH, (Point Huron) USNM; Washtenaw County (Ann Arbor) UMAH; Wayne County (Detroit) USNM; Counties unknown (Glen Haven) CAS, (Lake Huron shores) MCZ, (Newell's Camp) MCZ, (Pentwater) CNHM.

MINNESOTA: Chisago County (No locality given) UMSP; Clearwater County (Bohall Lake, Itasca State Park) UMSP, (De Soto Lake, Itasca State Park) UMSP; Crow Wing County (Mille Lacs Lake, near Garrison) UMSP, (Pelican Lake, Nisswa) UNLN; Douglas County (Alexandria) UASM, (Lake Carlos) ISNH, PUM; Hennepin County (Minneapolis) UMSP; Kandiyohi County (Eagle Lake, Willmar) UMSP; Olmsted County (No locality given) UMSP; Traverse County (No locality given) UMSP;

Wright County (No locality given) UMSP; County unknown (Vineland) UMSP. NEBRASKA: Cherry County (Hackberry Lake) UNLN, (Niobrara River, 3.5 miles northeast of Valentine) OSUC; Dakota County (South Sioux City) UNLN; Hall County (Junction U. S. 34 and Platte River, near Grand Island) UASM; Holt County (No locality given) UNLN. NEW HAMPSHIRE: Cheshire County (Swanzey Pond) MCZ. NEW JERSEY: Warren County (Phillipsburg) CAS; County unknown (Guymard) AMNH. NEW YORK: Erie County (Buffalo) ISNH; Orange County (Pine Island) CUNY; Tompkins County (Ithaca) CAS, CUNY, VMKi, UASM; Washington County (No locality given) MCZ; Westchester County (Golden's Bridge) CUNY; County unknown (Sandy Hill) CAS, (Varna) UASM. OHIO: Darke County (No locality given) UMSP; Erie County (Cedar Point) UMSP, (San dusky) PUM; Wood County (Yellow Creek) PUM. OKLAHOMA: Cleveland County (Norman) CAS; Marshall County (Lake Texoma, Willis) RCGr; Payne County (Stillwater) OSUS. PENNSYLVANIA: Allegheny County (No locality given) CMPP; Montour County (Danville) CAS; Northampton County (Easton) CAS; Westmoreland County (Jeannette) CMPP. RHODE ISLAND: Providence County (Providence) CMPP, UWMW. SOUTH DAKOTA: Beadle County (Huron) VMKi; Harding County (Buffalo) VMKi; Kingsbury County (Erwin) USNM. TEXAS: Blanco County (2.0 miles south of Round Mountain) UASM; Taylor County (25.0 miles southwest of Abilene) CNHM; Travis County (Austin) WSUP; County unknown (Belfrage) USNM. VERMONT: Bennington County (Hoosick River, Pownal) RTBe; Chittenden County (La Moille River, Milton) RTBe; Franklin County (La Moille River, East Georgia) RTBe; Rutland County (Poultney River, Fair Haven) RTBe, (Poultney River, Poultney) RTBe. VIRGINIA: Fairfax County (Great Falls) MCZ. WISCONSIN: Dane County (No locality given) UWMW;

Oconto County (Mountain) CNHM; Waupaca County (Waupaca) USNM, UWMW.

Figs. 394-397. Pronotum, right half, dorsal aspect. 394. *Brachinus vulcanoides* new species, Milton, Massachusetts. 395. *Brachinus oxygonus* Chaudoir, Archbold Biology Station, Florida. 396. *Brachinus fulminatus* new species, Great Swamp, Rhode Island. 397. *Brachinus janthinipennis* (Dejean), Toronto, Canada. Figs. 398-409. Male genitalia. 398. *Brachinus oxygonus* Chaudoir, Archbold Biology Station, Florida, ventral aspect. 399. Lateral aspect of same. 400. Dorsal aspect of same. 401. *Brachinus janthinipennis* (Dejean), Toronto, Canada, ventral aspect. 402. Lateral aspect of same. 403. Dorsal aspect of same. 404. *Brachinus vulcanoides* new species, Milton, Massachusetts, ventral aspect. 405. Lateral aspect of same. 406. Dorsal aspect of same. 407. *Brachinus fulminatus* new species, Edgewood, Maryland, ventral aspect. 408. Lateral aspect of same. 409. Dorsal aspect of same. Accompanying scale lines equal 1.0 mm.



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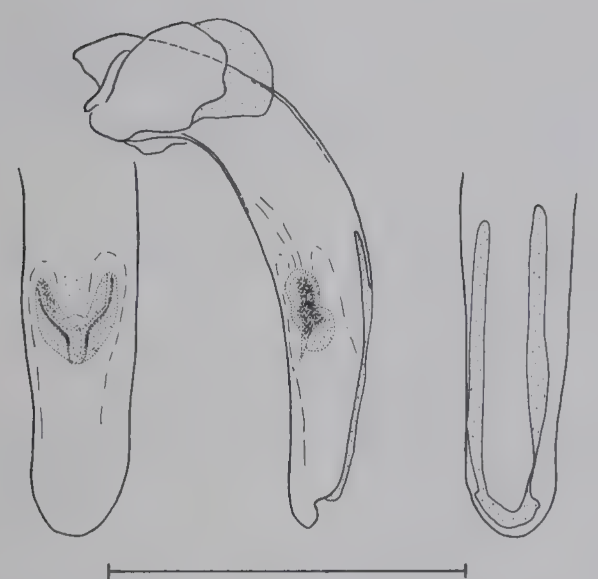

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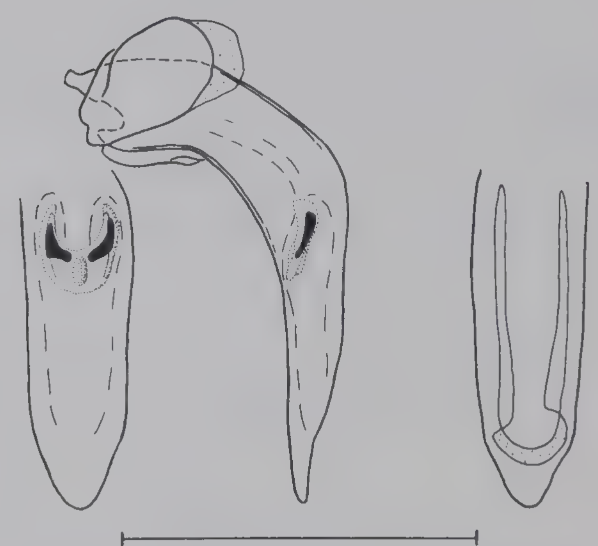

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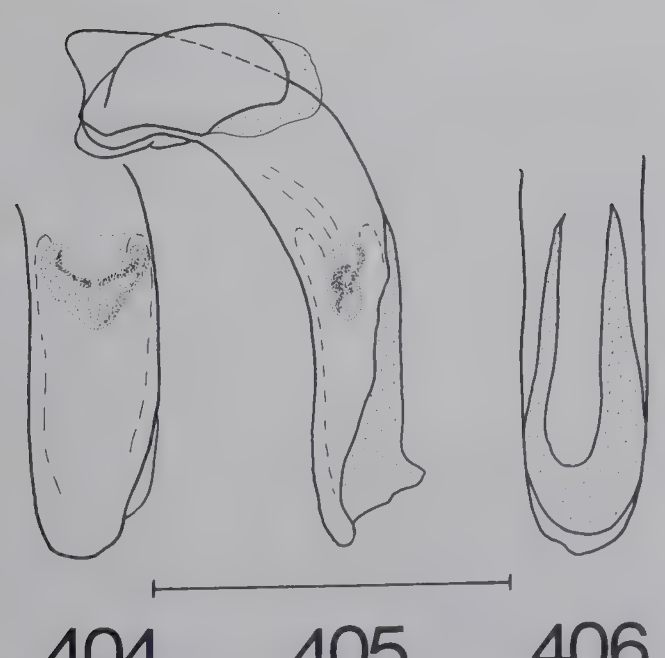

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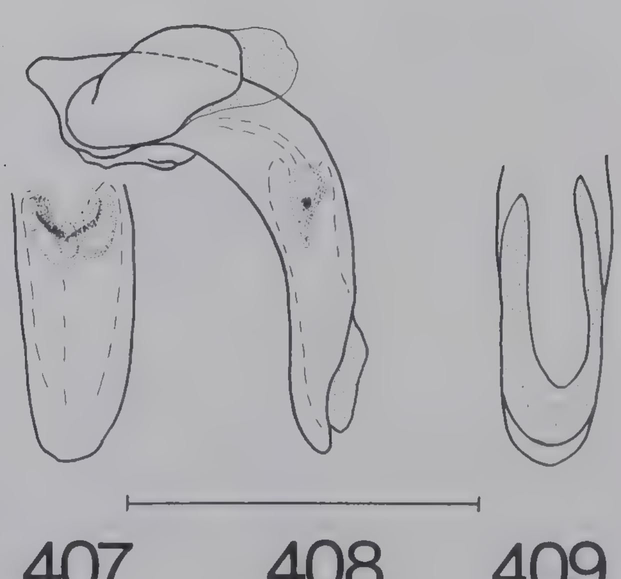

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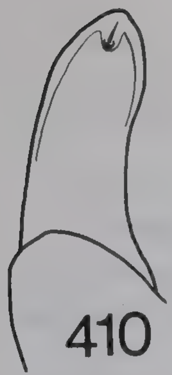
Figs. 410-413. Right stylus of female ovipositor. 410. Brachinus vulcanoides new species, Milton, Massachusetts. 411. Brachinus fulminatus new species, Edgewood, Maryland. 412. Brachinus oxygonus Chaudoir, Archbold Biology Station, Florida. 413. Brachinus janthinipennis (Dejean), Toronto, Canada. Figs. 414-417. Geographical distribution maps. 414. Brachinus fulminatus new species. 415. Brachinus vulcanoides new species. 416. Brachinus oxygonus Chaudoir. 417. Brachinus janthinipennis (Dejean). Accompanying scale line equals 1.0 mm.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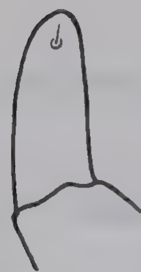
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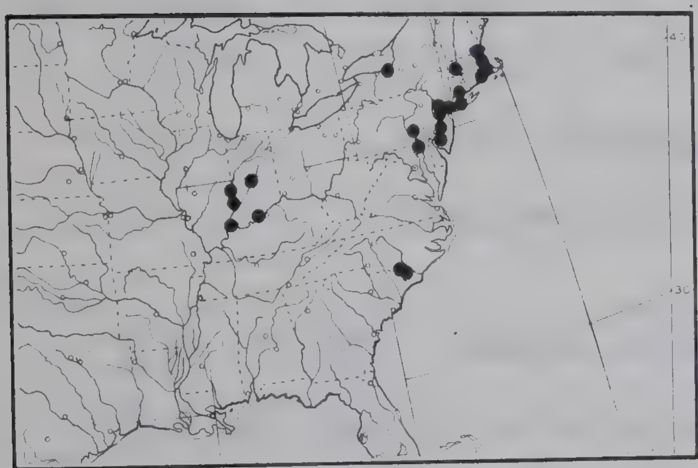
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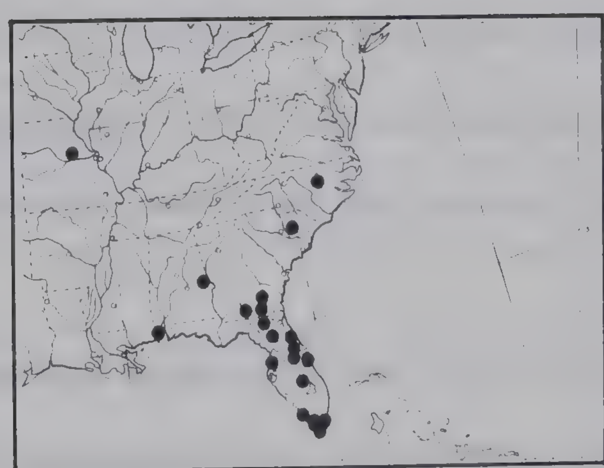
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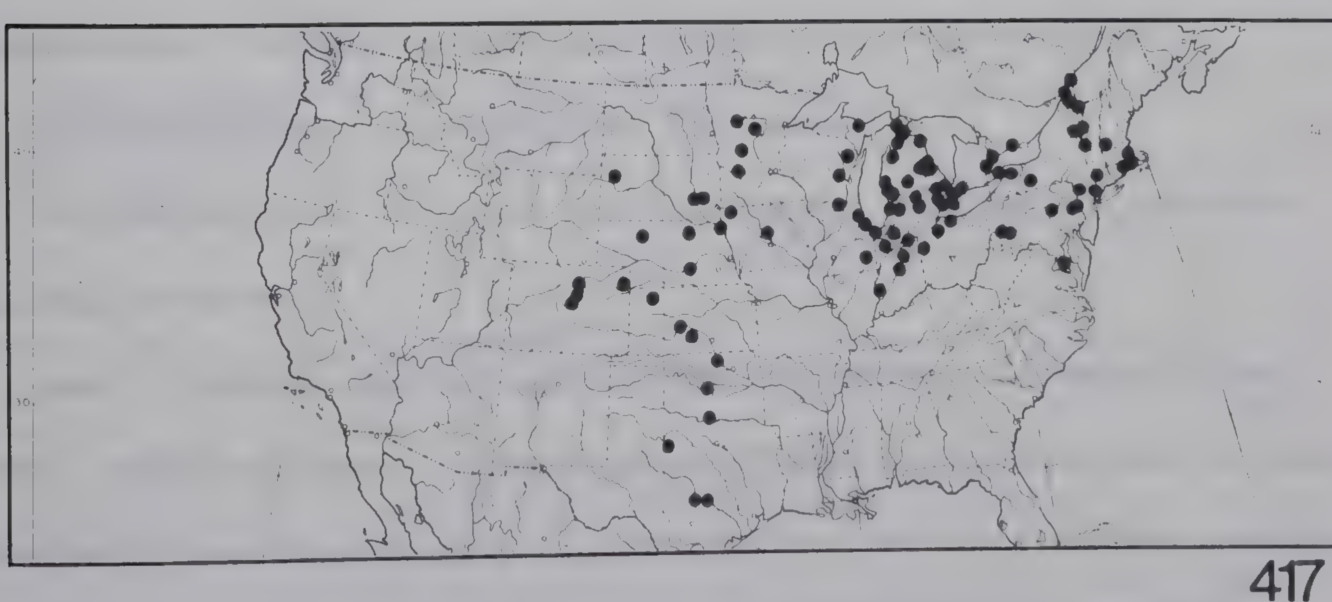
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4.704 The *mobilis* subgroup

The species of this subgroup are characterized by the virga and sulcate mentum surrounded by setae. The virga has the cross-brace of the "H" displaced to the apex and the pigmented areas more extensive, crossing the midline to form a bar. One species, *B. mobilis* new species, is included.

4.7041 *Brachinus mobilis* new species

(Figs. 420, 424, 425, 426, 435, 448)

Type locality.—Mobile, Alabama.

Type specimens.—The holotype male and allotype female are in CUNY. Both were collected at the type locality by H. Dietrich on March 19, 1932. One paratype collected at the same place is in CAS, MCZ, TLEr.

Diagnostic combination.—The sulcate mentum and completely pubescent elytra separate these beetles from all others in North America.

Description.—Medium-sized beetles, 8.0 to 8.8 mm.

Color. Antennal articles 2-4, mesepimera, metepisterna, sides of metasternum, and abdominal sterna and terga infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra blue.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows rugose, surface of pronotum shallowly punctate.

Head. Frontal furrows moderately impressed. Antennal scape robust, widest at apex. Ligula with sclerotized center area ellipsoid-convex with two lateral rows of three setae per row. Mentum sulcate at middle, sulcus surrounded by setae. Submentum with numerous

accessory setae, not shortened as in costipennis.

Prothorax. Pronotum (fig. 420) slightly convex, flattened along center line, sides narrowly reflexed. Proepipleura glabrous. Proepisterna with a few setae anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior edge punctate.

Pterothorax. As in cordicollis, except costae weakly elevated.

Abdomen. As described for genus.

Genitalia. Male (figs. 424, 425, 426). Median lobe with plane of shaft rotated 45^{o} from plane of basal bend. Basal bend moderately long. Median lobe arcuate, apex of shaft broadly rounded. Ligule short, broad, truncate. Virga (figs. 424, 425). Female (fig. 435). Stylus broad basally, tapering to acute apex.

Variation.—Too few specimens are known to evaluate geographic variation.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Latin, mobilis = mobile; referring to the beetle's ability to run rapidly, and to Mobile, Alabama, the place the types were collected.

Life history.—The five known specimens were collected in March, and none were teneral.

Distribution.—(Fig. 448). I have seen five specimens from the following locality:

UNITED STATES

ALABAMA: Mobile County (Mobile) CUNY.

4.71 The explosus group

This group is provisional until the male is known. The very

shiny and almost black elytra plus the very convex shape of the elytra seem to indicate that the single species, B. explosus new species, forms a separate group.

4.7101 Brachinus explosus new species
(Figs. 419, 443, 447)

Type locality.—Tamazunchale, San Luis Potosi, Mexico.

Type specimens.—The holotype female is in MCZ. It and the single female paratype were collected at the type locality by W. Nutting and F. Werner on May 30, 1948. I have retained the paratype on loan.

Diagnostic combination.—The very shiny, almost black elytra with pubescence restricted to the outer intervals separate members of this species from all others.

Description.—Medium-sized beetles, 9.9 to 10.7 mm.

Color. Antennal articles 3 and 4, mesepisterna, mesepimera, metepisterna, metasternum, and abdominal sterna and terga infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra almost black, shiny.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows rugose and sparsely punctate. Disc of pronotum finely rugose. Punctures barely impressed.

Head. Frontal furrows moderately impressed. Antennal scape robust, widened toward apex. Ligula with sclerotized center area ellipsoid-convex with two apical setae. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 419) convex, slightly flattened along center line, sides narrowly reflexed. Proepipleura glabrous.

Proepisterna with a few setae both anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior surface punctate.

Pterothorax. Elytra long, narrow, very convex, costae moderately elevated. Humeral angle prominent or at least square. Depressions punctate. Pubescence confined to outer intervals, except in apical third. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male unknown. Female (fig. 443). Stylus short, broad, apically acute.

Variation.—Too few specimens are known to evaluate geographic variation.

Flight.—Both known specimens were collected at lights.

Etymology.—Latin, explosus = drive off, burst; referring to the crepitating ability of these beetles.

Collecting notes.—The two known specimens were collected at light in an open river bottom at 682 feet elevation.

Life history.—Both specimens were collected in May, and neither was teneral.

Distribution.—(Fig. 447). Known only from the following locality:

MEXICO

SAN LUIS POTOSI: (Tamazunchale) MCZ.

4.72 The aabaaba group

The species of this group are characterized by the trilobed virga and its orientation on the endophallus, the sulcate ventral side of the median lobe and the slate-grey elytral color. Two

species, B. aabaaba new species and B. sonorous new species, are included.

4.7201 Brachinus aabaaba new species

(Figs. 421, 431, 432, 433, 434, 449)

Type locality.—Presa de Guadalupe, 55.3 miles west of Ciudad del Maiz, San Luis Potosi, Mexico.

Type specimens.—The holotype male and allotype female are in MCZ. Both were collected at the type locality by G. E. Ball and D. R. Whitehead on October 14, 1965. Four paratypes are in AMNH, CAS, MCZ, TLEr, and UASM.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 7.3 to 9.6 mm.

Color. Antennal articles 3 and 4, metepisterna, metasternum at sides, abdominal sterna and terga, and knees infuscated, otherwise ferrugineous. Dorsal surface and epipleura of elytra slate-grey.

Microsculpture. As described for genus.

Macrosculpture. Frontal furrows rugose and punctate. Surface of pronotum punctate, punctures barely impressed.

Head. Frontal furrows moderately impressed. Antennal scape slender, almost cylindrical. Ligula with sclerotized center area ellipsoid-convex with two lateral rows of three setae per row. Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 421) slightly convex, flattened on disc, sides slightly reflexed. Surface with numerous setae. Proepipleura and proepisterna pubescent anteriorly and posteriorly, glabrous medially. Anterior tibia with anterior surface shallowly

strigose.

Pterothorax. Elytra elongate, weakly costate. Humeral angle square. Costae and depressions pubescent. Wings fully developed.

Abdomen. As described for genus.

Genitalia. Male (figs. 431, 432, 433). Median lobe with plane of shaft rotated very little from plane of basal bend. Basal bend long. Median lobe arcuate, narrow throughout. Apex of shaft narrowly rounded, ventral side with two parallel ridges forming a central sulcus. Ligule short, truncate. Virga (figs. 431, 432). Female (fig. 434). Stylus short, broad basally, curving to narrowly rounded apex.

Variation.—Excepting the normal variation in body size and shape of the pronotum in local populations, this species is rather constant throughout it range.

Flight.—The flight of these beetles has been recorded repeatedly at lights in Texas.

Etymology.—Aabaaba, a barbaric combination of letters.

Life history.—These beetles were collected from April to October, but no teneral adults were seen.

Distribution.—(Fig. 449). The range of this species extends throughout Texas and eastern New Mexico, north to Kansas and south to San Luis Potosi, Mexico. I have seen 107 specimens from the following localities:

MEXICO

SAN LUIS POTOSI: (Presa de Guadalupe) UASM.

UNITED STATES

KANSAS: Atchison County (Atchison) CMPP; Seward County (No locality

given) KSU. NEW MEXICO: Eddy County (Carlsbad) GRNo, (White's City) FDAG; Quay County (San Jon) CAS. TEXAS: Aransas County (Goose Island State Park, 9.0 miles north of Rockport) UASM; Bexar County (San Antonio) OSUS; Blanco County (Cypress Mill) USNM; Brazos County (College Station) UMKi; Cameron County (Brownsville) CAS, CNC, JSch, TAMU, TLEr, USNM, WHTy, (Esperanza Ranch, Brownsville) CAS; Colorado County (Columbus) USNM; Cottle County (Peducah) JSch; Dallas County (Dallas) USNM; Dimmit County (No locality given) UATA; Dawson County (Lamesa) TCBa; Hidalgo County (McAllen) UMAH, (Weslaco) TAMU; Hudspeth County (9.0 miles southwest of Dell City) AMNH; Kleburg County (Kingsville) CNC, CUNY, USNM; Nueces County (Corpus Christi) CUNY; Potter County (Amarillo) UWSW; Randall County (Palo Duro State Park) UMSP; Reeves County (Pecos) CNC; San Patricio County (Welder Wildlife Refuge, near Sinton) CNC; San Saba County (Camp San Saba) MCZ; Travis County (Austin) CUNY, UASM, USNM; Victoria County (Victoria) USNM.

4.7202 *Brachinus* *sonorous* new species

(Figs. 422, 428, 429, 430, 436, 446)

Type locality.—Fourteen miles southwest of Empalme, Sonora, Mexico.

Type specimens.—The holotype male and allotype female are in CAS. Both were collected at the type locality by H. A. Hacker on May 1, 1962. One paratype is in AMNH, and TLEr.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Medium-sized beetles, 7.5 to 9.0 mm.

Color. Testaceous to ferrugineous. Dorsal surface of elytra

slate-grey, epipleura paler.

Microsculpture. As described for genus.

Macrosculpture. As in aabaaba.

Head. As in aabaaba.

Prothorax. Pronotum (fig. 422) as in aabaaba. Proepipleura and proepisterna pubescent throughout. Anterior tibia with anterior surface strigose.

Pterothorax. Elytra as in aabaaba.

Abdomen. As described for genus.

Genitalia. Male (figs. 428, 429, 430). Median lobe with plane of shaft rotated slightly from plane of basal bend. Basal bend long. Median lobe arcuate, narrow throughout. Apex of shaft narrowly rounded, ventral side with central sulcus formed by two parallel ridges. Ligule short, narrow and truncate. Virga (figs. 428, 429). Female (fig. 436). Stylus short, broad at base, tapering to narrowly rounded apex.

Variation.—Too few specimens are known of this species to evaluate geographic variation.

Flight.—The flight of these beetles has not been recorded.

Etymology.—Latin, sonorous = sound; referring to the crepitating habit of these beetles and to the type locality in Sonora, Mexico.

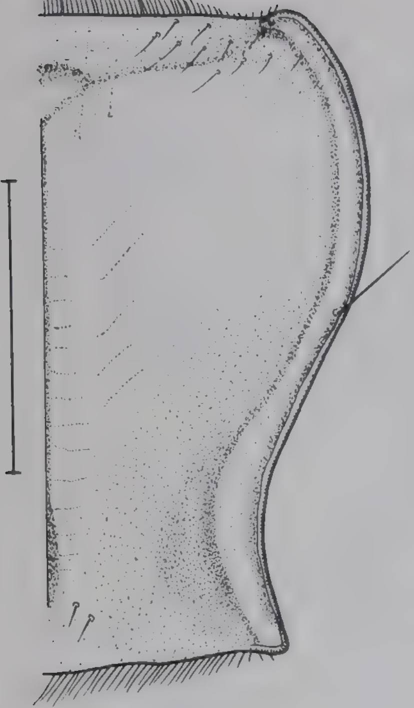
Life history.—Members of this species have been collected in May and July, but no teneral adults were seen.

Distribution.—(Fig. 446). This species is known from only two localities on the west coast of Mexico. I have seen four specimens from the following localities:

MEXICO

SINALOA: (Mazatlan) AMNH. SONORA: (14.0 miles southeast of Empalme) CAS.

Figs. 419-423, 427. Pronotum, right half, dorsal aspect. 419. Brachinus explosus new species, Tamazunchale, San Luis Potosi, Mexico. 420. Brachinus mobilis new species, Mobile, Alabama. 421. Brachinus aabaaba new species, Presa de Guadalupe, San Luis Potosi, Mexico. 422. Brachinus sonorous new species, 14.0 miles southeast of Empalme, Sonora, Mexico. 423. Pheropsophidius aequinoctialis Linné, Amazonas, Brazil. 427. Pheropsophidius biplagiatus Chaudoir, 22.4 miles north of Puerto Escondido, Oaxaca, Mexico. Figs. 424-426, 428-433. Male genitalia. 424. Brachinus mobilis new species, Mobile, Alabama, ventral aspect. 425. Lateral aspect of same. 426. Dorsal aspect of same. 428. Brachinus sonorous new species, Mazatlan, Sinaloa, Mexico, ventral aspect. 429. Lateral aspect of same. 430. Dorsal aspect of same. 431. Brachinus aabaaba new species, Presa de Guadalupe, San Luis Potosi, Mexico, ventral aspect. 432. Lateral aspect of same. 433. Dorsal aspect of same. Accompanying scale lines equal 1.0 mm.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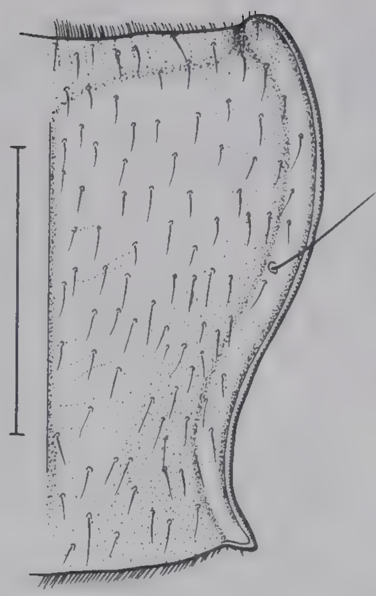
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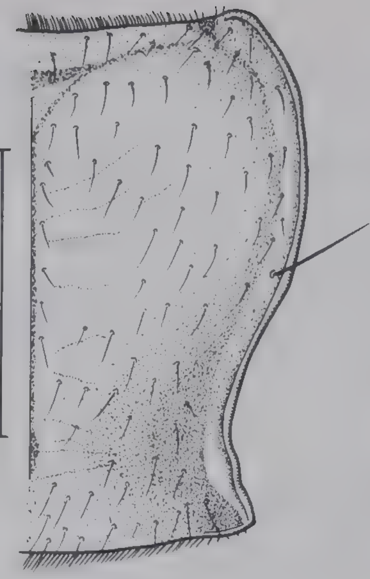
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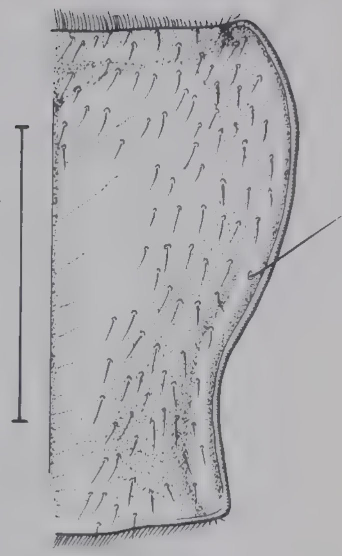
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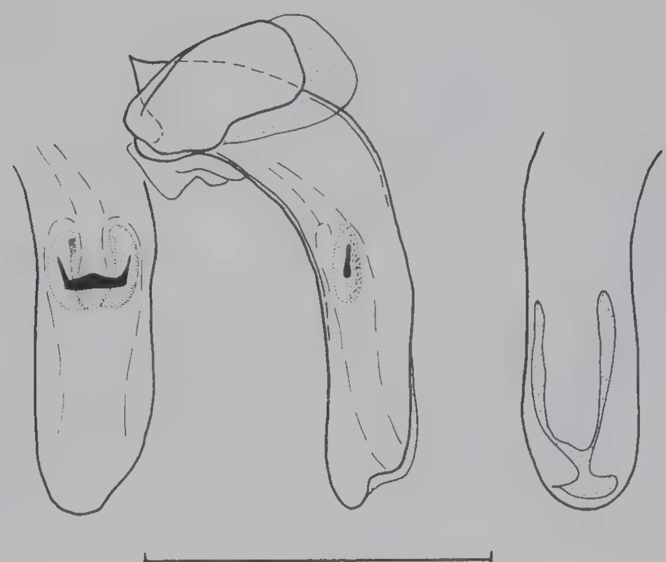
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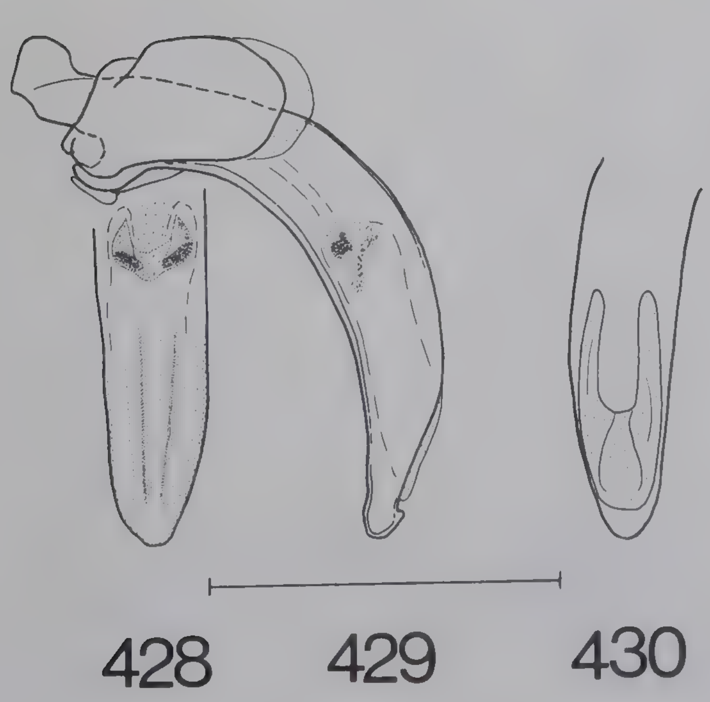
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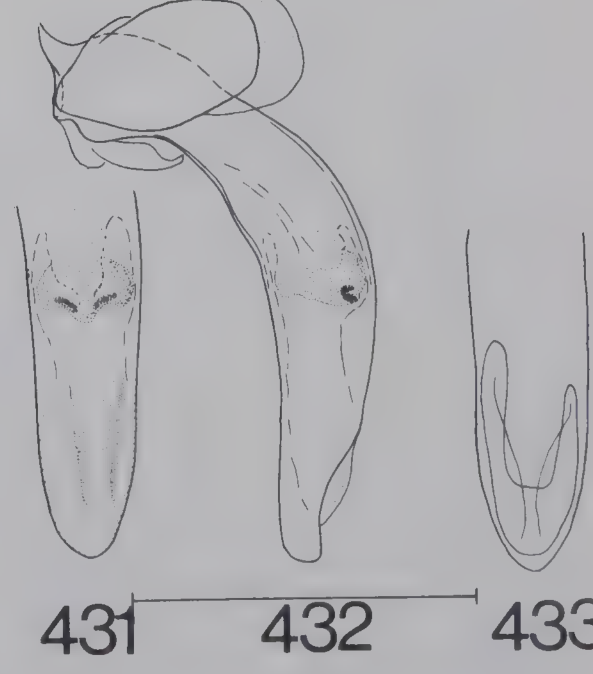
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Figs. 434-436, 443-445_1. Right stylus of female ovipositor, ventral aspect. 434. Brachinus aabaaba, new species, Presa de Guadalupe, San Luis Potosi, Mexico. 435. Brachinus mobilis new species, Mobile, Alabama. 436. Brachinus sonorous new species, 14.0 miles southeast of Empalme, Sonora, Mexico. 443. Brachinus explosus new species, Tamazunchale, San Luis Potosi, Mexico. 444. Pheropsophidius biplagiatus Chaudoir, 22.4 miles, north of Puerto Escondido, Oaxaca, Mexico. 445_1. Pheropsophidius aequinoctialis (Linné), Amazonas, Brazil. Figs. 437-439, 440-442. Male genitalia. 437. Pheropsophidius biplagiatus Chaudoir, 22.4 miles north of Puerto Escondido, Oaxaca, Mexico, ventral aspect. 438. Lateral aspect of same. 439. Dorsal aspect of same. 440. Pheropsophidius aequinoctialis (Linné), Amazonas, Brazil, ventral aspect. 441. Lateral aspect of same. 442. Dorsal aspect of same. Accompanying scale lines equal 1.0 mm.


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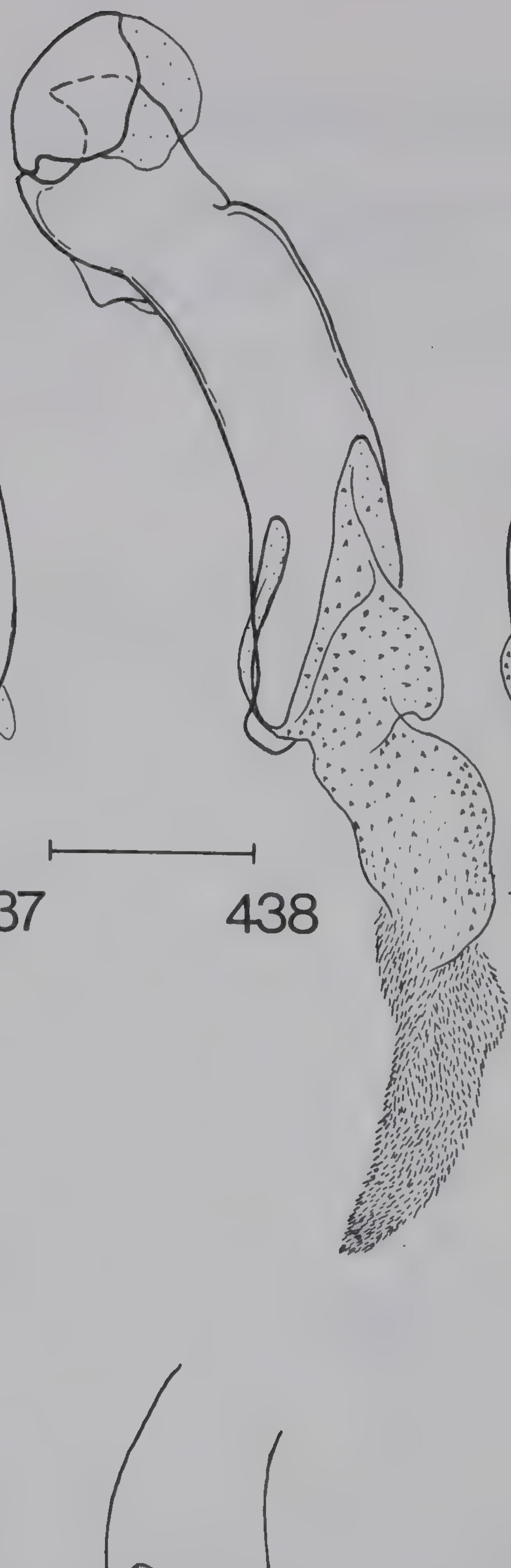
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Figs. 445_2-449. Geographical distribution maps. 445_2. Pheropsophidius biplagiatus Chaudoir. 446. Brachinus sonorous new species. 447. Brachinus explosus new species. 448. Brachinus mobilis new species. 449. Brachinus aabaaba new species.

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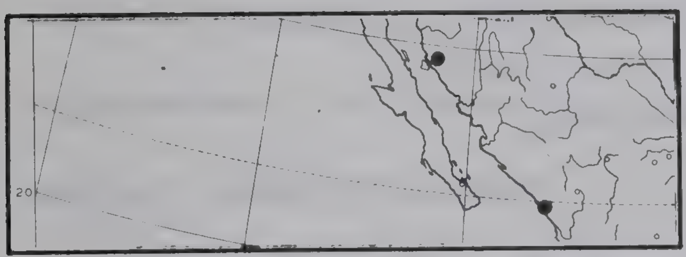

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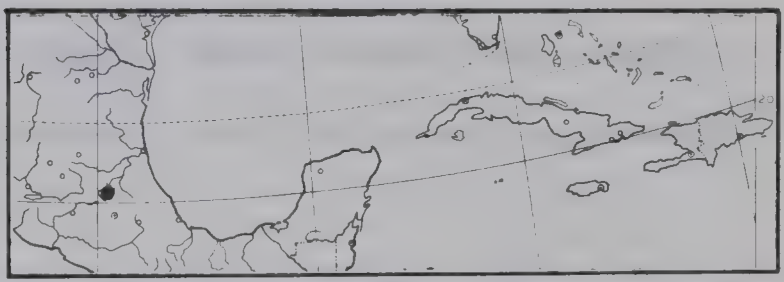

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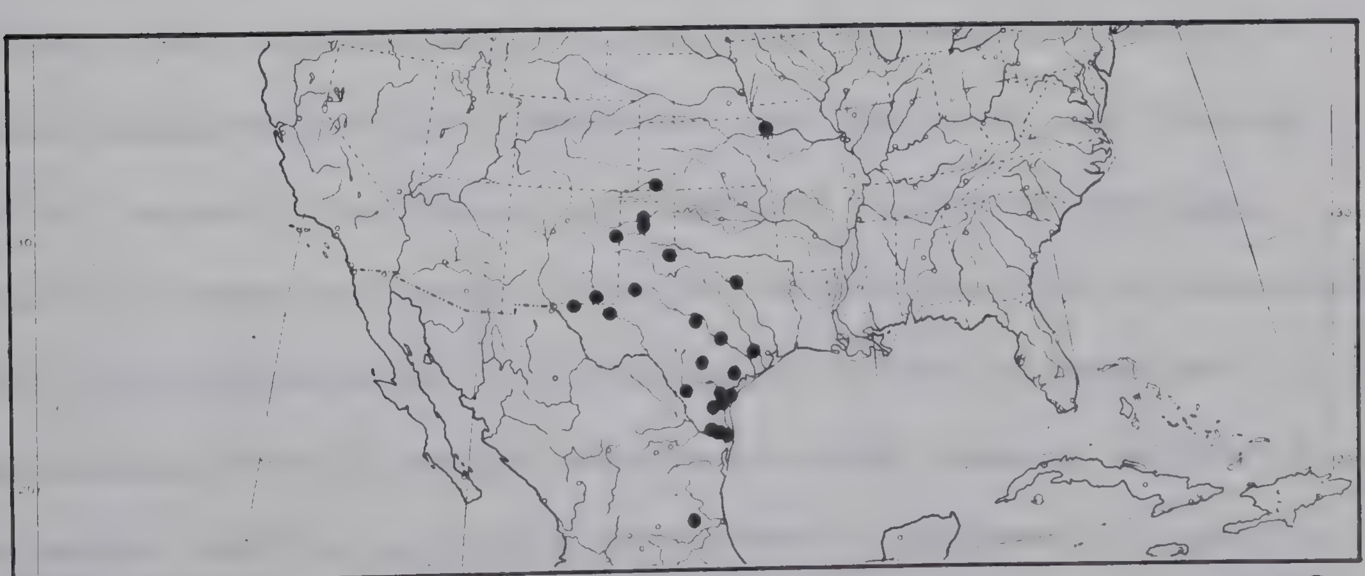


449

4.73 Fossil Material

Scudder (1900) described two _Brachinus_ species, _B. repressus_ and _B. newberryi_, from the Florissant beds of Colorado (Miocene). The material consists of fragments of elytra. I have seen only Scudder's illustrations of the two species. In both species the striae are well developed, unlike any existing _Brachinus_ members with the possible exception of _B. sallei_, whose members have punctate depressions. All other _Brachinus_ members have costae and depressions without traces of striae.

I doubt very much that members of _Brachinus sallei_ were in the northern part of the New World during the Miocene, since they are part of the _Brachinus_ that probably evolved in isolation in South America. These South American groups probably did not reach North America until the Pliocene, or later (see Section 7).

Concerning Scudder's assignment of these specimens to _Brachinus_, three possibilities come to mind. First, the specimens in question may not be the remains of _Brachinus_ at all. Scudder is known to have made incorrect generic assignments of other fossil material, which suggests that his knowledge was less than adequate for work with fossil carabids (see Ball, 1959; Ball and Erwin, MS; and Freitag, 1969). Secondly the remains may represent species of _Brachinus_ similar to those now extant, but the illustrations may be inadequate. Third, the fragments may represent an old extinct lineage with characteristics that are not present in extant species anywhere in the world. Until I have examined Scudder's specimens, I prefer to reserve final judgement concerning their placement.

northern part of the New World during the Miocene,

America. These South American grou

made incorrect generic assignments of other fossil

characteristics that are

the world. Until I have examined Scudder's specim

4.8 The genus *Pheropsophidius* in Middle America

Synonymy and characteristics are presented in Section 4.323.

4.81. The subgenus *Protopheropsophus* Hubenthal

Synonymy and characteristics are presented in Section 4.3232.

4.811 *Pheropsophidius biplagiatus* (Chaudoir)

(Figs. 427, 437, 438, 439, 444, 445_2)

Pheropsophus biplagiatus Chaudoir, 1876:18. Lectotype, here selected, a male, MHNP, labelled "Ex Museo Chaudoir" and standing first in a series of seven specimens. *Type locality*.—Oaxaca, Mexico, as given originally by Chaudoir.

Diagnostic combination.—The diagnostic characteristics are given in the key.

Description.—Large-sized beetles, 11.0 to 14.0 mm.

Color. Sides of abdomen at least and terga infuscated, otherwise ferrugineous. Dorsal surface of elytra dark brown, epipleura paler; disc of each elytron with ferrugineous spot.

Microsculpture. Head and pronotum with very fine irregular meshes approximating isodiametric meshes. Elytra with isodiametric meshes.

Macrosculpture. Elytral depression 1 in basal half, depressions 7 and 8 throughout with numerous microtubercles forming rugose surface.

Head. Frontal furrows barely impressed, smooth. Antennal scape robust, widest apically, shorter than eye diameter. Ligula carinate at middle with three setae at middle of carina and two apically.

Mentum and submentum without accessory setae.

Prothorax. Pronotum (fig. 427), convex, sides beaded, not reflexed.

Pterothorax. Elytra short, weakly costate. Humeri narrow, sloped. Metathorax very short, shorter than diameter of middle coxa.

Abdomen. As described for genus.

Genitalia. Male (figs. 437, 438, 439). Median lobe almost straight, notched dorsally at basal third, broadly rounded apically. Ligule bifid, each lobe shifted to alternate sides. Endophallus (fig. 438) long, microtrichiated, apex acute, apical half pubescent. Female (fig. 444). Stylus short, broad, rounded apically.

Variation.—Within a sample I have seen from a single population, there is considerable difference in body size and in the diameter of the elytral spots.

Flight.—These beetles are incapable of flight.

Etymology.—Latin, bi = two; Greek, plagio = slope, oblique; Latin, atus = provided with; probably referring to the angular apex of the elytra.

Collecting notes.—G. E. Ball and D. R. Whitehead collected these beetles in leaf litter on the southern slopes of the Sierra Madre del Sur. The forest consisted of *Quercus* species.

Life history.—Members of this species were collected in July, and two of these were teneral.

Distribution.—(Fig. 445_2). The range of this species is confined to the southern slopes of the Sierra Madre del Sur in Oaxaca, Mexico. I have seen 15 specimens from the following locality:

MEXICO

OAXACA: (22.4 miles north of Puerto Escondido) UASM.

4.82 The subgenus *Pheropsophidius* Hubenthal

Synonymy and characteristics are presented in Section 4.3231.

4.821 *Pheropsophidius aequinoctialis* (Linné)

(Figs. 423, 440, 441, 442, 445)

Bates (1883) records this species from the Yucatan Peninsula in Mexico. I have not seen specimens from anywhere in Middle America, and therefore, have only included "key characters." The species is quite divergent in South America, with many described "varieties."

5.0 LIFE HISTORIES AND IMMATURE STAGES

In 1967 I described the life history and behavior of *Brachinus pallidus* Erwin in California, and reviewed all available life history information concerning the bombardier beetles. Since then, I have reared a single first instar larva of *Brachinus mexicanus* Dejean from specimens G. E. Ball and I collected in Chiapas, and my wife and I collected a single last instar larva of either *Brachinus mexicanus*, *B. phaeocerus*, or *B. costipennis* in New Mexico.

I have chosen to delay the description of the first instar of *B. mexicanus* until more specimens are seen. The last instar specimen from New Mexico will also await description until comparative material of related species is available.

6.0 PHYLOGENY

6.1 Introduction

Ball (1966) wrote that "the study of evolution is the mainstream and unifying concept of biology, and the best way to join the study of Cryobius to this mainstream is to search for the evolutionary pathways of the extant species." Hennig (1956, 1966) provided principles that taxonomists may apply to their respective groups in order to show phylogenetic relationships. The first task, according to Hennig, is the recognition of a monophyletic group, then the search for its sister group. This process is repeated until the phylogeny is attained. At this point, Hennig writes that sister groups must have the same absolute rank in a phyletic system. I agree in principle, but I believe this to be practically impossible (see also, Ball and Erwin MS). With the addition of the numerous new categories and taxa created, any phylogeny would be so cluttered that relationships would be unclear. So long as named taxa are not polyphyletic (similarity due to convergence) or paraphyletic (similarity based on symplesiomorphy), and provided we can avoid a proliferation of names, we can eventually achieve a rational and usable classification that may reflect the phylogeny of the particular group of organisms under study. At least one phylogeneticist, Tuomikoski (1967), is willing to accept paraphyletic groups "sometimes" because of their "greater information content" and "better applicability to different branches of biology" outside pure phylogenetics. I have not recognized paraphyletic groups formally in the Division Brachinida. Brundin (1966, 1968) has summarized the

theory of phylogenetic systematics as advanced by Hennig.

I have applied Hennig's principles to the bombardier beetles, but only time and much additional study of these beetles might prove or disprove my hypotheses concerning the phylogeny of these taxa. Hennig's paleontological and parasitological methods are not applicable to bombardier beetles, because of the lack of fossils and the poor state of knowledge concerning ground beetle parasites. This leaves the holomorphological and chorological methods available, however, which I have used in arriving at my tentative phylogenetic arrangements.

6.2 The Division Brachinida

The bombardier beetles are a relatively recent derivative of the carabid line of evolution. The best evidence for this is the pattern of distribution which shows no large discontinuities (with the exception of Beringia), and few small discontinuities. (See Section 7).

These beetles are "Anisochaeta : Lobopleuri" in Bell's scheme (1967), except that I have found that the members of Mastacina and Pheropsophina have the middle coxal cavities conjunct-separated. Bell reports this condition only in Metrini, Ozaenini, and Omophronini, all judged to be primitive on the basis of other characteristics. Further, the hind coxal cavities of bombardier beetles are disjunct-lobate-confluent, with the exception of members of Mastax which have them disjunct-lobate-separated (and widely separated). This condition is reported by Bell as occurring only in Gehringiini and Rhysodini. Four other discrepancies arise when the bombardier beetles are placed

among the higher Carabidae (Anisochaeta: Lobopleuri): the seta in the mandibular scrobe; the extra visible abdominal segments; the medially located outlets of the pygidial glands; and the very pliable cuticle of the body and elytra. A discussion of each discrepancy follows.

Most of the "lower" Carabidae possess a seta in the scrobe of the mandible. *Trachypachus* has a pore there, but lacks the seta. The paussines and ozaenines lack the seta, but *Metrius* (a paussine in all other respects) has one. Omophronines, gehringiines, opisthiines, notiophilines, elaphrines, trechines, bembidiines, nebriines, psydrines, patrobines, pogonines, and rhysodids also possess a seta in the scrobe. The "lower" carabids without the seta (promecognathines, loricerines, siagonines, and paussids) have highly modified mandibles without scrobes. As far as I know, the seta is not present in scaritines or any higher carabids. This character seems to place the bombardier beetles somewhere in this primitive group. I believe, however, that the adult scrobal seta is homologous with the mandibular seta of the carabid larvae (characteristic of all carabid groups). If so, the loss of this seta in "higher" adult carabids which maintain the seta in their larval stages does not mean the gene complex governing the appearance of the seta is absent, but simply that the seta has lost its usefulness in the adult stage. Therefore, the neotenous appearance of this scrobal seta might occur in any group of carabids primitive or advanced.

The large number of visible abdominal segments (seven in the female, eight in the male) is a direct result of the highly specialized crepitating mechanism, and must have evolved with that apparatus. Considered by themselves, these extra exposed segments

would mean little when comparing bombardier beetles with other carabids.

The highly specialized crepitating mechanism, with its centrally located crepitating chambers and outlets, comprises the most outstanding difference between bombardier beetles and all other carabids. All other crepitating carabid beetles have lateral outlets and crepitating chambers. Metriines have very large reniform sclerotized "mixing" chambers laterad beneath tergum 9, with an outlet associated with tergum 8. Members of _Pachyteles_, an ozaenine, have smaller chambers than members of _Metrius_, but the location is the same. Members of the _Helluomorphoides_ have a spiraled tubular chamber laterad under tergum 8, but no large mixing chambers. _Pseudomorpha_ has a small tubular chamber laterad under tergum 8, and an outlet also in tergum 8. Members of _Galerita ruficollis_ Dejean, a galeritine, have a small chamber laterad beneath tergum 8, behind the spiracle. The internal glands empty into this lateral chamber directly. There is no large mixing chamber.

In contrast, the bombardier beetles have two large heavily sclerotized reniform mixing chambers associated with tergum 8. The complete tergum 9 is modified into twin crepitating chambers with the outlets medially centered, one on each side of the median keel. This type is clearly derivable from any of the other crepitating mechanisms, including those of _Metrius_ and _Pachyteles_ (both very primitive types in all other respects), by the medial displacement of the outlets, and by the modification of tergum 9 into twin crepitating chambers. This modification also makes this body segment externally visible, whereas it is entirely concealed in other carabids.

The general plasticity and toughness of the body cuticle of bombardier beetles is found elsewhere only in the Galeritini. When squeezed, the sclerites of these beetles do not break, they merely bend. I believe this is an adaptation that parallels the warning coloration and crepitating mechanism, and is necessary for Müllerian mimics (synaposematics). Trimen (1869) was the first to point out that mimetic butterflies were unusually tough, and could withstand light attacks by predators without being crushed or torn apart. Subsequent authors have expanded this notion (for example, Carpenter and Ford, 1933). The elasticity of the body cuticle and extra visible abdominal segments can perhaps be ignored in the search for the sister group of the Brachinida.

The seta of the scrobe is probably neotenous, and therefore must be regarded with caution. The crepitating mechanism is derivable from either primitive or advanced carabids and therefore contributes little of phylogenetic significance.

Another group of characters are seen in the anisochaete-lobopleurous condition of the bombardier beetles, which place them among the more advanced groups, as discussed by Bell (1967). There is no indication that this condition has evolved convergently in the carabids, and that possibility actually seems very unlikely.

Based on the above evidence, and other facts presented elsewhere in this paper, I consider the bombardier beetles to be a monophyletic group that has rather recently diverged from some extinct line of higher carabids. The identity of the extant sister group, if there be one, can only be determined by a careful study of those higher carabid groups, a feat possible only after the African and Oriental

faunas are much better known. The relative geological age of the bombardier beetles is discussed in Section 7.

Using the foregoing data, in addition to that given in Section 3, I believe that a hypothetical common ancestor to the bombardier beetles might be characterized as in Table 1 in the plesiomorphous column.

TABLE 1.

PLESIOMORPHOUS (PRIMITIVE) AND APOMORPHOUS (DERIVED) CONDITIONS OF SOME CHARACTERS OF BOMBARDIER BEETLES.

CHARACTER	PLESIOMORPHOUS	APOMORPHOUS
MICROSCULPTURE:		
Head, pronotum, and elytra	Isodiametric meshes	Slightly stretched transversely
HEAD:		
Color	Brown-ferrugineous	Black, yellow, or brown
Frontal furrows	Shallow	Deeply impressed
Antennal articles	Filiform	Flattened and quadrate or moniliform
Mandibles	Subfalciform	Larva-like
Scrobes	Unisetose	Plurisetose
Terminal palpal articles	Subcylindrical	Wedge-shaped or globose or securiform
Ligula	Bisetose	Plurisetose
Mentum	Entire	Toothed

CHARACTER	PLESIOMORPHOUS	APOMORPHOUS
PROTHORAX:		
Color	Brown-ferrugineous	Black, yellow or brown
Outline of pronotum	Cordate	Paralleliform
Propleural suture	Fused with remnant ridge	Fused and smooth
Anterior coxal cavities	Biperforate-separate-open	Uniperforate-separate-closed
MESOTHORAX:		
Coxal cavities	Conjunct-confluent	Conjunct-separate
Mesepisterna	Present	Absent
ELYTRA:		
Pubescence	Present	Absent
Umbilicate setae	Uninterrupted	Two sets of eight setae
Erect setae	Short	Long
Intervals	Costate	Carinate or flat
Humeral angle	Square	Sloped
METATHORAX:		
Metepisternum	Long	Short
Metepimera lobe	Small	Large
Metasternum	Long	Short
Coxal cavity	Conjunct-confluent	Conjunct-separate
Wings	Caraboid, veins present	Distinct veins absent

CHARACTER	PLESIOMORPHOUS	APOMORPHOUS
ANTERIOR LEGS:		
Femoral vestiture	Scattered pubescence	Rows of short stiff setae
Subterminal spur	Internal on top of comb	External
Tarsal articles	Symmetrical	Asymmetrical
Male tarsal vestiture	Longitudinally arranged	Diagonally or circularly arranged
ABDOMEN:		
Segments	Seven or eight exposed	Unchanged
MALE GENITALIA:		
Median lobe	Symmetrical	Twisted right or left
Parameres	Asymmetrical and not balteate	Asymmetrical balteate
Ligule	Absent	Present
Endophallus	Microtrichiated in part	Sclerotized in part
FEMALE GENITALIA:		
Bursa copulatrix	Membraneous	Sclerotized
Valvifer	Glabrous	Setiferous
Coxite	Glabrous	Setiferous
Stylus	Glabrous	Uni-setiferous

6.3 The tribes, genera, and subgenera

As indicated in fig. 450, the ancestral species underwent differentiation, giving rise to the ancestor of the crepidogastrine stock and the mastacine-aptinine-pheropsophine-brachinine stock. The crepidogastrine stock gave rise to at least seven lineages, according to Basilewsky (1959). He ranks the seven extant groups (three of which are monotypic, and two others are represented by only two known species) as genera within the tribe Crepidogastrini. Tentatively, however, I would suggest, based on the picture I have presented for the other bombardier beetles, that Basilewsky's genera should be placed at the subgeneric rank.

The data available are not sufficient to apply Hennig's Principles to these beetles.

The differentiation of the Crepidogastrini stock from the other Brachinini involved the following derived characters which stand out as true synapomorphies in the Crepidogastrini: palpi securiform; gular sutures narrowed behind; male anterior tarsal vestiture spongy-pad type; mesepimeron shortened or absent. On the other hand, the apomorphous condition of the balteate parameres is a condition of the Brachinini male genitalia and never evolved in the crepidogastrine lineage.

Later the Brachinini underwent differentiation into the pheropsophine-mastacine lineage and the brachinine-aptinine lineage. The former line evolved the apomorphous condition of setae on the basal margin of the mandibles, and the separated middle coxal cavities, while the latter evolved the apomorphous condition characterized by uniperforate anterior coxal cavities.

Fig. 450. Hypothetical phylogeny for the major taxa of the Division Brachinida based on the methods of detecting sister groups proposed by Hennig (1966). Note that open circles represent single ancestral species. Character states 1-49 are listed in Table 2. Black rectangles represent apomorphous character states. White rectangles represent plesiomorphous character states.

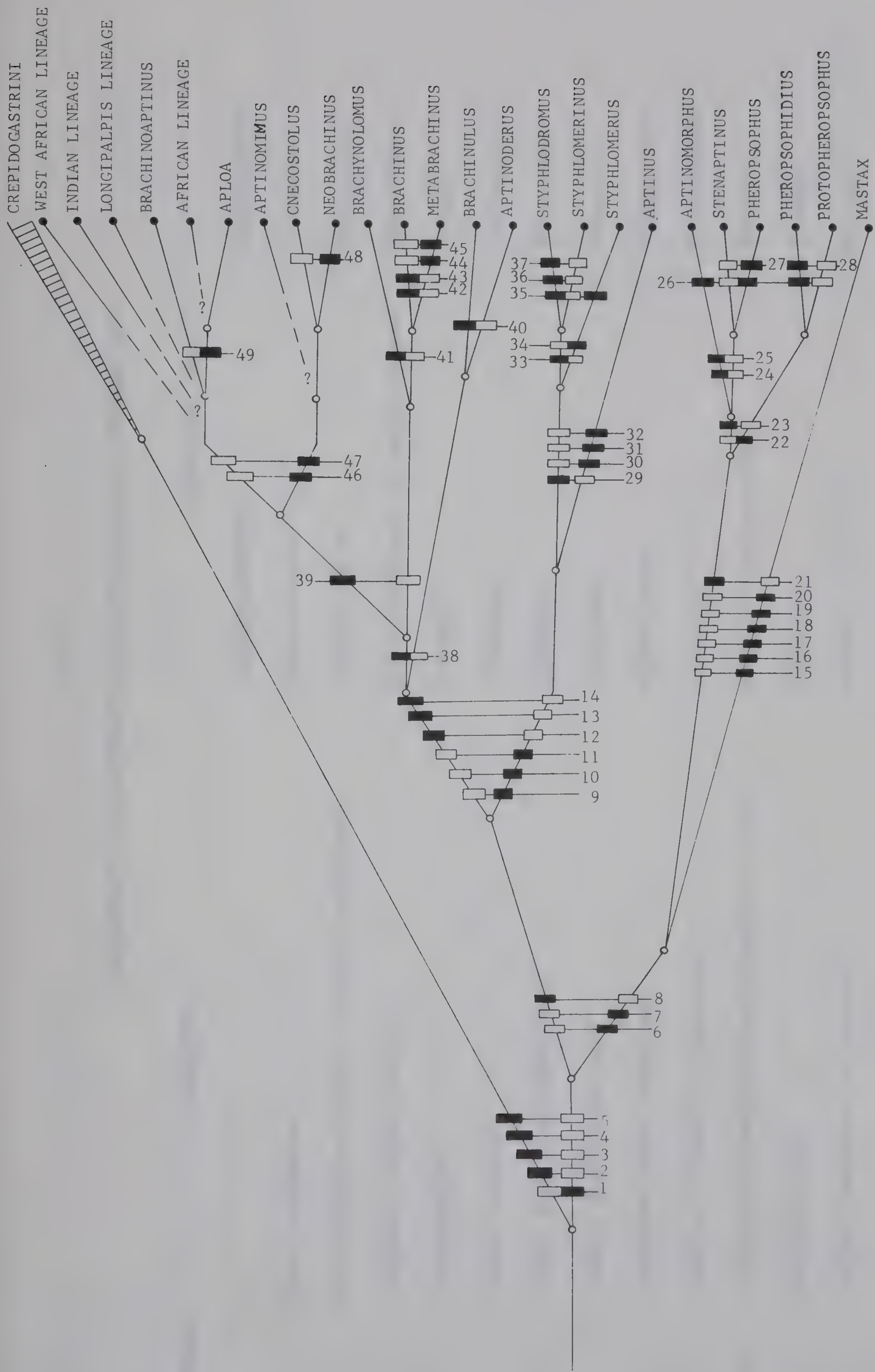

CREPIDOGASTRINI
WEST AFRICAN LINEAGE
INDIAN LINEAGE
LONGIPALPIS LINEAGE
BRACHINOAPTINUS
AFRICAN LINEAGE
APLOA
APTINOMIMUS
CNECOSTOLUS
NEOBRACHINUS
BRACHYNOLOMUS
BRACHINUS
METABRACHINUS
BRACHINULUS
APTINODERUS
STYPHLODROMUS
STYPHLOMERINUS
STYPHLOMERUS
APTINUS
APTINOMORPHUS
STENAPTINUS
PHEROPSOPHUS
PHEROPSOPHIDIUS
PROTOPHEROPSOPHUS
MASTAX

TABLE 2.

PLESIOMORPH AND APOMORPH CHARACTERS USED IN FIGURE 450.

NUMBER	CHARACTER	CHARACTER STATE	
		PLESIOMORPHOUS	APOMORPHOUS
1.	Male parameres'	Non-balteate	Balteate
2.	Male anterior tarsal article vestiture"	Parallel rows	Spongy pads
3.	Terminal palpal article'	Subcylindrical or wedge-shaped	Securiform
4.	Mesepimeron'	Present	Absent
5.	Gular sutures"	Diverging	Converging
6.	Basal margin of mandible"	Glabrous	Setiferous
7.	Middle coxal cavities"	Confluent	Separate
8.	Anterior coxal cavities"	Biperforate	Uniperforate
9.	Coxite of female ovipositor"	Glabrous	Plurisetose
10.	Specialized setae of male anterior tarsi"	Scroll-like apically	Rounded
11.	Mental tooth"	Absent	Present
12.	Apical membrane of elytra"	Absent	Present
13.	Mandibular scrobe"	Unisetose	Plurisetose

NUMBER	CHARACTER	CHARACTER STATE	
		PLESIOMORPHOUS	APOMORPHOUS
14.	Upper spur of antennal comb'	Internal	External or almost so
15.	Mandibular scrobe"	Present	Effaced
16.	Basal margin of mandible"	Partially setiferous	Completely setiferous
17.	Metasternal process'	Acute	Broadly rounded
18.	Mandibular tooth"	Very small	Large
19.	Hind coxal cavities'	Confluent	Separate
20.	Dorsal notch at basal bend of male genitalia"	Absent	Present
21.	Upper spur of antennal comb'	Present	Absent
22.	Propleural suture"	Present	Absent
23.	Elytral intervals"	Costate	Carinate
24.	Elytral carinae"	Wide and rounded	Narrow and sharp
25.	Apical elytra membrane"	Fringed	Glabrous
26.	Anterior coxal cavities'	Open	Closed
27.	Female styli"	Short and spatulate	Elongate and narrow
28.	Discal elytral depressions"	Microtuberculate	Smooth
29.	Setae of coxite of female ovipositor"	Cylindrical	Flat

NUMBER	CHARACTER	CHARACTER STATE	
		PLESIOMORPHOUS	APOMORPHOUS
30.	Male median lobe "	Tubular	Contorted
31.	Bursal sclerites of female genitalia"	Absent	Present
32.	Endophallus of male genitalia"	Long	Very short
33.	Dorsal surface of body"	Micropunctate	Macropunctate
34.	Ligule of male genitalia"	Single	Double
35.	Color pattern of elytra"	Spotted	Concolorous
36.	Mental tooth"	Strong	Reduced or absent
37.	Folding pattern of endophallus"	Simple	Complete
38.	Apical membrane of elytra"	Partially developed	Fully developed
39.	Vestiture of male anterior tarsi"	Asymmetrical	Symmetrical
40.	Terminal palpal article"	Fusiform	Wedge-shaped
41.	Apical sclerite of endophallus"	Absent	Present
42.	Apical elytral membrane"	Fringed	Widely spaced setae
43.	Left paramere of male genitalia"	Small and balteate	Large and triangulate
44.	Color pattern of elytra"	Concolorous	Spotted
45.	Apical elytral membrane"	Fringed	Glabrous

NUMBER	CHARACTER	CHARACTER STATE	
		PLESIOMORPHOUS	APOMORPHOUS
46.	Virga of endophallus"	Absent	Present
47.	Upper spur of antennal comb"	Slightly internal	External
48.	Antennal article three"	Short	Elongate
49.	Subapical sclerite of endophallus"	Absent	Present

' = Objectively determined, that is the character state was determined to be apomorphous by its distribution throughout the Carabidae.

" = Subjectively determined, that is the character state was determined to be apomorphous by its distribution throughout the Brachinida or part thereof.

From the pheropsophine-mastacine lineage two stocks were derived, the aberrant Mastax and the more conservative Pheropsophina. The former evolved the following synapomorphies: well-developed bifid retinacular mandibular teeth; extension of mandibular basal margin brush to the tooth; loss of a mandibular scrobe; rounded metasternal process between middle coxae; separated hind coxal cavities. The Pheropsophina stock evolved the apomorphous condition of a dorsal notch at the basal bend of the male median lobe. Within the Pheropsophina two lines arose, the second one replacing the first in all areas except the New World. The first, or more primitive, stock of the Pheropsophina, retained the costate elytral condition, but lost the propleural suture. This stock reached the New World, but subsequently, was not eliminated by a second wave of advanced Pheropsophina, which had carinate elytra. This second wave arrived in eastern Asia too late to cross into the New World.

Once in the New World, the primitive Pheropsophina remained in isolation (see Section 7) and underwent secondary radiation into two subgenera, Protopheropsophus and Pheropsophidius. Protopheropsophus retains the open anterior coxal cavities (a very primitive condition in carabid beetles), but it has lost the small rugosities in the depressions of the elytra, and has become wingless.

In the second radiation of Old World Pheropsophina, the ancestral stock of one group, Aptinomorphus, evolved the apomorphous condition of narrow, acute carinae, and lost the apical elytral fringe setae. Also from this second radiation came the subgenera Stenaptinus and Pheropsophus (sensu stricto). Pheropsophus attained the apomorphous condition of elongate styli in the female, while Stenaptinus has

retained the primitive spatulate styli and the nearly-open anterior coxal cavities.

The aptinine-brachinine lineage split very early into two ancestral stocks, the Aptinina and the Brachinina. The Aptinina stock attained the apomorphous condition of a toothed mentum, anterior male tarsal articles with apically disc-shaped setae in the ventral vestiture, and setiferous coxite. The Brachinina stock became apomorphous in the presence of the elytral membrane and the presence of pubescence in the scrobe of the mandible. At that point, it is possible that both stocks had asymmetrical anterior tarsal articles in the male, but in one lineage of Brachinina those articles later became symmetrical. A second alternative is that tarsal asymmetry developed convergently in Aptinina and part of Brachinina. It should be pointed out, however, that the modified setae of Aptinina members are disc-shaped at the apex (figs. 43, 47), whereas in all Brachinina members, including the ones with asymmetrical tarsal articles, the setae are expanded and rolled like a scroll at the apex (figs. 41, 42, 44, 45, 46, 49).

Subsequently, the Aptinina lineage evolved into the Aptinus stock and Styphlomerus stock. The Aptinus members became wingless mountain inhabitants of southern Europe, while the Styphlomerus stock converged in habitus and coloration with the Brachinina members, and subsequently spread as far as Japan. The Aptinus stock acquired the apomorphous conditions of bursal sclerites in the female, and a swollen and contorted median lobe in the male. Within this stock the apical opening of the shaft became contorted to the right in one group, while in the other (the extant Aptinus displosor Dufour) the opening contorted to the left. Both groups have a very short internal

sac with several sclerites.

The Styphlomerus stock acquired the apomorphous condition of modified setae on the coxite, then subsequently divided into two lines. The first of these, represented by the members of Styphlomerus, acquired the apomorphous condition of a double ligule on the male median lobe, while the Styphlodromus-Styphlomerinus line acquired the apomorphous condition of macropunctate elytra. The members of Styphlodromus subsequently lost the mental tooth that was originally developed in the Aptinina stock. I have interpreted this character state as being apomorphic, and those beetles also became apomorphic in the complex folding pattern of the endophallus.

Meanwhile, the Brachinina were undergoing a rather extensive radiation, resulting in at least 14, extant lineages. The Brachinina are extremely difficult to sort out, because externally they exhibit very little diversity, due perhaps to the strong selective pressures of Müllerian mimicry (see Section 3). In order to determine the likely phylogenetic pathways, the internal sac and its associated sclerites, or microtrictiated fields, should be carefully studied. In areas such as Africa and the Orient, the species are very poorly known and material is difficult to obtain. However, with the material available, I have applied Hennig's principles, and I believe that a reasonable picture emerges that can be used as a basis for further study.

After the split of the Brachinina from the aptinine-brachinine lineage, another split occurred as the apomorphous elytral membrane became more fully developed. A few extant species, Aptinoderus (=Brachynomorphus) and Brachinulus remain, however, with the poorly

developed membrane. Brachinulus became apomorphous in the swollen-acuminate last palpal articles. Aptinoderus represents the most primitive (plesiomorphous) group of species in the entire lineage. These species are wingless and highly endemic.

The lineage with the fully developed elytral membrane subsequently diverged into two lines of evolution. One of these lines acquired symmetrical male anterior tarsal articles, while the other line retained the previously acquired asymmetrical condition. I have discussed this character state above. It is difficult to say whether it is the result of convergence in the Aptinina and part of the Brachinina, or a gain of asymmetry in the aptinine-brachine-lineage long ago and subsequent reversion to symmetry in part of Brachinina. I favor the latter view because of the asymmetry in Aptinoderus males. These beetles are in the most plesiomorphic state of the Brachinina and, therefore are morphologically the most similar to the Aptinina. Nevertheless, it does serve to unite two lines of evolution within the higher Brachinina, regardless of which line is apomorphic for the character state.

The "asymmetrical" lineage subsequently split (1) into an apomorphous line with a virga on the endophallus of the male genitalia, and (2) a plesiomorphic line. The former, the Brachynolomus stock, remained basically pleisiomorphous in all character states except the virga, while the second line later subdivided into the more northern Brachinus (sensu stricto) and the southern Metabrachinus. The members of Brachinus (sensu stricto) acquired the apomorphous condition of long widely-spaced setae on the apical elytral membrane and the large triangular left paramere. The members of Metabrachinus

became apomorphous by the loss of setae on the apical elytral membrane and by acquiring a spotted color pattern on the elytra, but remained pleisiomorphic in the character states mention for Brachinus (sensu stricto).

The "symmetrical" lineage subsequently split into (1) an apomorphous line with a virga on the internal sac of the male genitalia and (2) a plesiomorphic line, just as did the "asymmetrical" lineage. In the line which acquired a virga, a further apomorphous condition arose when the spur of the antennal comb became external. The "virgate" line subsequently split into two groups, Neobrachinus and Cnecostolus, the common ancestor of which had split from the ancestor of Aptinomimus. Since I have not seen the male genitalia of Aptinomimus, I cannot place it exactly into the scheme. However, on the basis of the female characteristics, this group appears to be the southern vicar of this lineage (see Section 7).

The Old World Cnecostolus acquired the apomorphous conditions of a spotted color pattern of the elytra, and the edge of the apical elytral membrane became glabrous or almost so. Also, the virga of these beetles seems to be of a different nature than in Neobrachinus. The Neobrachinus lineage acquired the apomorphous condition of an elongate antennal article 3, which is longer than articles 1 and 2 combined, and the "socket-type" closing of the anterior coxal cavities.

In the "non-virgate" plesiomorphic line of the symmetrical lineage, the upper spur of the anterior tibia has remained slightly internal, in an intermediate position. This line split, forming the ancestor of the extant Aploa and Brachinoaptinus. The former acquired

the apomorphous condition of a subapical sclerite on the endophallus of the male genitalia, and a spotted elytral color pattern. The ancestral stock of Brachinoaptinus remained pleisomorphic in the character states discussed, and represents the ancestral stock of the "symmetrical" lineage.

I have seen specimens representing at least four other lineages not discussed above. Two of these are from India and the others are from Africa. Because of insufficient material, I cannot determine their affinities, but they belong to the "symmetrical" line, and probably have been derived from the Aploa-Brachinoaptinus ancestral stock.

6.4 The North and Middle American species of Neobrachinus

The methods used in this Section are the same as I used in determining the phylogeny of the supra-specific taxa of Brachinida. It has been necessary to use the evolution of form of the virga in order to determine the primary branching points in figure 451. The underlying assumption in the study of the virgae is that change has proceeded from a simple to a more complex structure. The geographical distribution of members with the simple type virga supports this assumption.

The comparison of the virga of Neobrachinus in comparison with that of Old World groups indicates that this subgenus is monophyletic. Brachinus dryas Andrewes (= stenoderus Andrewes) of the Himalayan region must be regarded as a member of subgenus Neobrachinus, and it is the only species from outside the New World that I know to have a Neobrachinus-type virga. All other characteristics of this species

agree with the New World group; also for this reason, I regard Brachinus dryas as an Old World relic of the lineage that later crossed into North America (see also Section 7). Because of the homologous nature of the virgae of all the North and Middle American Neobrachinus, I believe that a single ancestral form crossed the Bering Land Bridge and subsequently radiated into the present pattern. The foregoing data, in addition to that given in Section 4.5, convinces me that the common ancestor of the species of Neobrachinus can be characterized in Table 3, pleisomorphous column.

TABLE 3.

PLESIOMORPHOUS AND APOMORPHOUS CONDITIONS OF SOME CHARACTERS OF Neobrachinus.

CHARACTER	PLESIOMORPHOUS	APOMORPHOUS
COLOR:		
Head and prothorax	Ferrugineous	Black or brown
Elytra	Blue	Black, brown, green, slate-grey, striped
Elytral epipleura	Blue	Testaceous
Mesepisterna	Ferrugineous	Brown or infuscated
Metepisterna	Infuscated	Ferrugineous or brown
Metasterna	Ferrugineous	Infuscated at sides
Abdomen	Infuscated	Ferrugineous, brown, or infuscated at sides only
Terga	Infuscated	Ferrugineous
Legs	Ferrugineous	Black or testaceous
Knees	Ferrugineous	Infuscated

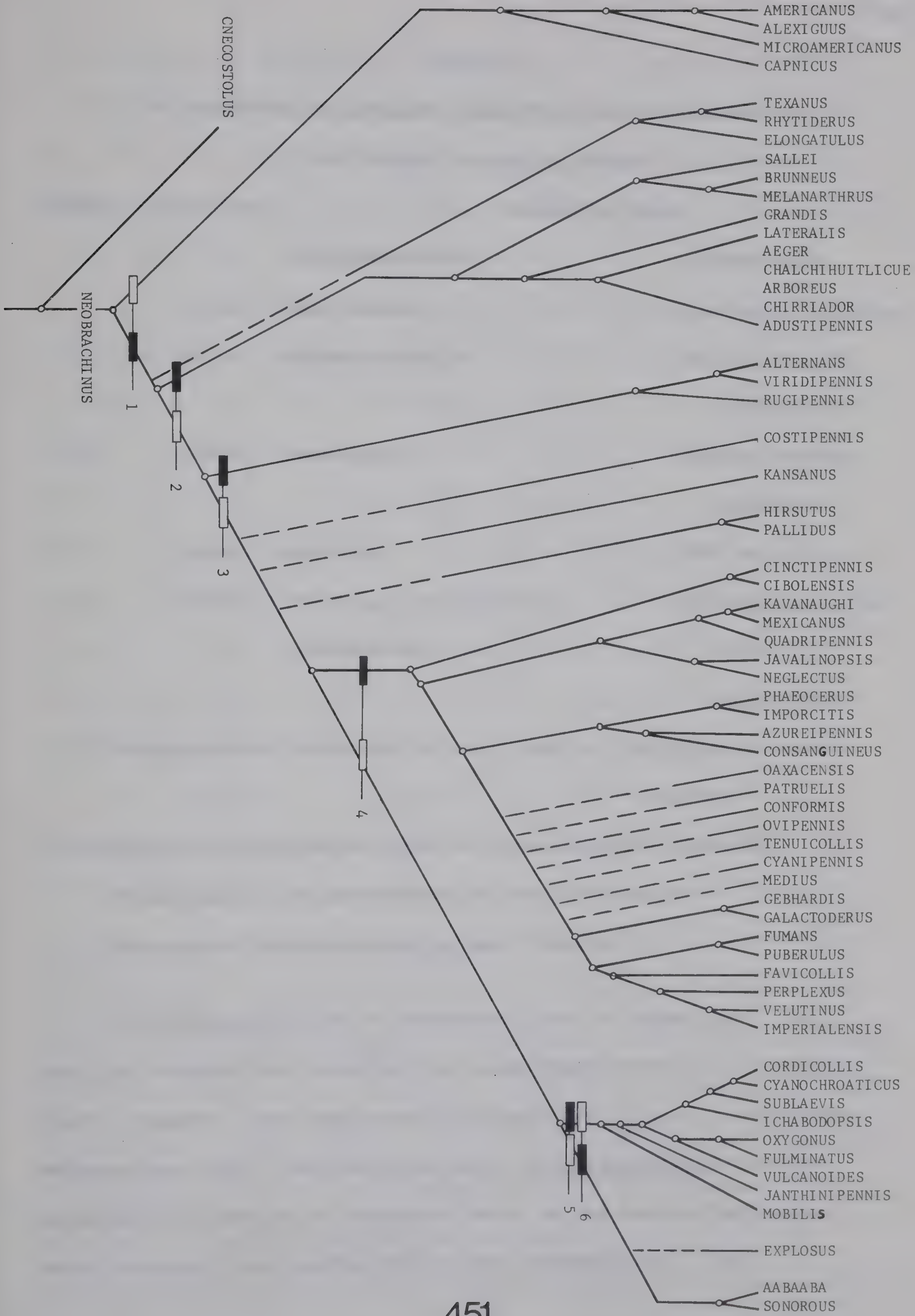
CHARACTER	PLESIOMORPHOUS	APOMORPHOUS
HEAD:		
Frontal furrows	Shallow	Deep
Mentum	Flat to slightly convex at middle	Unisulcate or bisulcate
Submentum	Long	Short
Mental setae	Two	Plurisetose
Submental setae	Eight to ten	Sixteen to twenty or more
PRONOTUM:		
Outline of pronotum	Cordate	Narrow
Lateral setae	Present	Absent
Pronotal pubescence	Scattered	Dense or absent
Proepipleural pubescence	Absent	Scattered or confined anteriorly and posteriorly
Proepisternal pubescence	Scattered	Absent or confined anteriorly and posteriorly
ELYTRA:		
Costae	Moderately elevated	Highly elevated or absent
Humeral angle	Square	Sloped
Erect depression setae	Subequal to pubescence	Three or more times longer than pubescence
Pubescence	Evenly scattered	Restricted to intervals 6, 7, 8, or to 8, or absent

CHARACTER	PLESIOMORPHOUS	APOMORPHOUS
METATHORAX:		
Metasternum, metepisternum	Long	Short
LEGS:		
Anterior surface of anterior tibia	Strigose	Punctate
MALE GENITALIA:		
Basal bend	Same plane as shaft	Rotated from plane of shaft
Virga	Simple	Complex

Based upon these hypothetical features, I have tried to align the species of Neobrachinus into a developmental cline based upon the complexity of the virga. The starting point is the americanus group, the members of which have a virga almost identical to that of B. dryas of the Himalayan region. Further, the americanus group includes species that are wingless, which I believe shows some indication of ancient lineage. The following discussion is graphically illustrated in figure 451.

The virga of members of the americanus group is simply the lightly sclerotized tip of the endophallus, and there are also two lightly pigmented areas, one on each side of the gonopore. This virga is the most pleisomorphic of the series, and is identical to that of members of B. dryas Andrewes in Sikkim.

Fig. 451. Hypothetical phylogeny for the species of North and Middle American genus Brachinus based on the methods of detecting sister species proposed by Hennig (1966). Primary branches numbered 1-6 described in Table 4. Unnumbered branches described in text, Section 6.4. Note that open circles represent single ancestral species. Black rectangles represent apomorphous character states. White rectangles represent plesiomorphous character states.



CNECOSTOLUS
NEOBRACHINUS
AMERICANUS
ALEXIGUUS
MICROAMERICANUS
CAPNICUS
TEXANUS
RHYTIDERUS
ELONGATULUS
SALLEI
BRUNNEUS
MELANARTHRUS
GRANDIS
LATERALIS
AEGER
CHALCHIHUITLICUE
ARBOREUS
CHIRRIADOR
ADUSTIPENNIS
ALTERNANS
VIRIDIPENNIS
RUGIPENNIS
COSTIPENNIS
KANSANUS
HIRSUTUS
PALLIDUS
CINCTIPENNIS
CIBOLENSIS
KAVANAUGHI
MEXICANUS
QUADRIPENNIS
JAVALINOPSIS
NEGLECTUS
PHAEOCERUS
IMPORCITIS
AZUREIPENNIS
CONSANGUINEUS
OAXACENSIS
PATRUELIS
CONFORMIS
OVIPENNIS
TENUICOLLIS
CYANIPENNIS
MEDIUS
GEBHARDIS
GALACTODERUS
FUMANS
PUBERULUS
FAVICOLLIS
PERPLEXUS
VELUTINUS
IMPERIALENSIS
CORDICOLLIS
CYANOCHROATICUS
SUBLAEVIS
ICHABODOPSIS
OXYGONUS
FULMINATUS
VULCANOIDES
JANTHINIPENNIS
MOBILIS
EXPLOSUS
AABAABA
SONOROUS
1
2
3
4
5
6

TABLE 4.

PLESIOMORPH AND APOMORPH CHARACTERS USED IN FIGURE 451 FOR PRIMARY BRANCHING POINTS

NUMBER	CHARACTER	CHARACTER STATE: PLESIOMORPHOUS	CHARACTER STATE: APOMORPHOUS
1.	Virga"	Pouch-shaped	Variously modified
3.	Virga"	Rounded apically	Acute apically, tripartite
4.	Virga"	Unmodified	Ventral trough centrally
5.	Virga"	Unmodified	"H" shaped
6.	Virga"	Continuous with axis of endophallus	Perpendicular to axis of endophallus
2.	Zoogeographic	Isolation in South America	Isolation in North America

" = Subjectively determined, that is, the character state was determined to be apomorphous by its distribution throughout the Brachinida or part thereof.

The americanus group is subdivided into two subgroups. The capnicus subgroup has acquired the apomorphous condition of totally black integument, and must have differentiated long ao. The second subgroup next split and gave rise to *B. microamericanus* with the apomorphous condition of accessory setae on the mentum, and with setae anteriorly and posteriorly on the proepipleura. The

B. americanus-B. alexiguus lineage acquired the apomorphous male genitalia and the punctate anterior surface of the anterior tibiae. This lineage divided to produce the very similar B. americanus and B. alexiguus. B. alexiguus acquired the apomorphous condition of infuscated antennal articles 3 and 4.

The next lineage must be considered here because it contains the modern members of an early group or groups isolated in South America throughout most of the Cenozoic Era (see Section 7). The members representing the ancestral stock that invaded South America from the north are represented by B. nigricans and B. niger, both now extant in South America. These species are probably of similar antiquity to those of the americanus group. During the Pliocene, species that had evolved in South American isolation invaded Mexico (via Central America) and North America. These various groups are considered below.

The texanus group includes many South American species not considered in this paper, therefore only tentative conclusions can be reached at this time. The stock moving out of South America split, giving rise to B. elongatulus and the ancestral stock of the B. rhytiderus-B. texanus lineage. The later then split, giving rise to B. rhytiderus and B. texanus. The determination of plesiomorphous-apomorphous conditions is difficult without studying more species of this group. It seems however, that the more rounded female stylus of B. elongatulus and its more elongate elytra may be apomorphous, while the loss of accessory setae of the mentum and the loss of discal elytral setae may be apomorphous in B. rhytiderus. The slate-grey elytra and densely pubescent elytral depressions are certainly

apomorphous in _B. texanus_.

The other groups that evolved in isolation in South America are those with the apomorphous condition of brown elytra. This lineage must have split long ago, giving rise to a stock with the apomorphous condition of brown head and prothorax, matching the color of the elytra. Two groups of this stock have invaded Middle America. The _sallei_ group acquired the apomorphous condition of two paramedian pits in the mentum, while the _brunneus_ group remained similar to forms in South America (such as _B. hyalea_ Reichardt). The older lineage which gave rise to the _sallei_-_brunneus_ stock, also gave rise to a complex and diverse group of beetles that I have tentatively placed in the _lateralis_ group. Judging from the characteristics of the virgae and male median lobes, this group is far from being understood. A complete study of the South American _Neobrachinus_ with brown elytra will have to be undertaken before the taxonomy of this complex group is understood.

Both the _kansanus_ group and the _costipennis_ group contain only single, rather aberrant species, neither showing any relationship to other extant _Brachinus_. Members of _B. kansanus_ have acquired the apomorphous condition of the lack of lateral pronotal setae, highly elevated (almost carinate) costae, and narrowly reflexed side margins of the pronotum. The virga is only slightly modified from the _americanus_ type, in that only the dorsal apex has become sclerotized, but the pigmented areas near the gonopore are extensive.

The members of _B. costipennis_ are probably the most aberrant of the subgenus _Neobrachinus_. The mentum is deeply sulcate, with the single pit surrounded by setae. This character state is surely

apomorphous. Other apomorphous conditions are the glabrous elytra, the almost carinate costae, the shape of the apex of the median lobe and the shortened submentum. The virga is unlike any others, but could easily have been derived from the _americanus_ type.

The virga of the _alternans_ group is highly aberrant and its deriviation cannot be easily hypothesized. This stock probably split from the main line of evolution long ago, as indicated by the flightless condition in one of its species. The lineage split, giving rise to _B. rugipennis_, which acquired the apomorphous condition of a wide ligule of the male median lobe, and to a stock containing the forebears of _B. alternans_ and _B. viridipennis_. Ultimately, _B. alternans_ acquired the apomorphous condition of a broad stylus in the female ovipositor, while _B. viridipennis_ developed the apomorphous green elytra, punctate anterior surface of the anterior tibiae, and elongate apex of the median lobe.

The next group, the _hirsutus_ group, consists of two closely related sister species that show no close relationship to other groups in the structure of the virga. The ancestral stock acquired the apomorphous condition, of a compressed median lobe, strongly costate elytra, and the loss of lateral pronotal setae. This stock diverged, giving rise to _B. hirsutus_ and _B. pallidus_. The former acquired the apomorphous conditions of a depression on the venter of the shaft of the male genitalia, and a densely pubescent pronotum. The latter developed a more compressed shaft of the male median lobe. The virga of this group was clearly derivable from the _americanus_ type by a reduction in dorsal and ventral sclerotization, leaving two lateral lobes connected in the area of the gonopore.

The members of the _fumans_ group have similarly constructed virgae, but exhibit great diversity among the members. The virga is essentially like that of the _americanus_ group, but the ventral surface has lost its sclerotization and the sides have curled over, ventrally, leaving a central trough. Once this type of virga has arisen, the lineage split, forming the _cinctipennis_ subgroup and the ancestral stock of the other _fumans_ subgroups. The _cinctipennis_ subgroup acquired the apomorphous condition of a ferrugineous sutural stripe on the elytra. The other ancestral stock subsequently divided, giving rise to the ancestors of the _quadripennis_ and other subgroups.

The _quadripennis_ subgroup developed the apomorphous condition of a ridge on the venter of the shaft of the male median lobe, and has diverged into two sister stocks, one with the apomorphous smooth anterior tibiae with only punctures on the anterior surface, and accessory setae on the submentum. This line subsequently split to form _B. neglectus_, with its apomorphous acute styli, and _B. javalinopsis_ with its apomorphous plurisetose ligula. The other sister stock also divided, giving rise to _B. quadripennis_ with its apomorphous spatulate and broad stylus of the female ovipositor, and infuscated palpi and tibiae, and to the ancestral stock of _B. mexicanus-B. kavanaughi_. This stock subsequently divided giving rise to the species mentioned. _B. mexicanus_ acquired the apomorphous condition of reduced elytral pubescence and _B. kavanaughi_ has remained the most plesiomorphic of the lineages, probably being representative of the ancestral stock.

The sister stock of the _quadripennis_ subgroup subsequently divided, giving rise to the _phaeocerus_ subgroup, with its apomorphous conditions

of a long narrow apex on the shaft of the male median lobe, the bright blue elytra with contrasting black suture, and the black outer antennal articles. This ancestral stock diverged giving rise to two sister stocks. One of these acquired the apomorphous condition of completely pubescent proepisterna and proepipleura. This line subsequently split giving rise to B. azureipennis, with its apomorphous black tibiae and tarsi, and B. consanquineus. The other line subsequently split, giving rise to B. phaeocerus, with its apomorphous bent apex of the shaft of the male median lobe, and its infuscated tibiae and tarsi, and B. imporcitis with its apomorphous glabrous proepisterna.

At this point in the evolution of the fumans group, numerous divergences occurred, none of which left morphological characteristics that can be interpreted using Hennig's principles. That is none of these numerous species have evident sister relationships with other species or groups. B. oaxacensis acquired the apomorphous conditions of a lack of lateral pronotal setae, an elongate and strongly sclerotized virga, and highly raised and ridge-like costae. B. patruelis acquired the apomorphous condition of two accessory ligules on the shaft of the male genitalia. B. conformis acquired the apomorphous condition of a narrow and chisel-shaped shaft of the male genitalia, and an elongate and narrow stylus of the female ovipositor. B. ovipennis acquired the apomorphous condition of a compressed and collapsed shaft of the male median lobe, and slight rotation in the orientation of the virga within the shaft. B. tenuicollis acquired the apomorphous condition of an elongate and very narrow shaft of the male median lobe, highly elevated costae of the elytra, and the broad

styli of the female ovipositor. _B. cyanipennis_ acquired the apomorphous condition of a broad ligule of the shaft of the male median lobe, and elongate erect depression setae. _B. medius_ acquired the apomorphous condition of small wide styli of the female ovipositor.

After these groups diverged from the _fumans_ lineage, the main ancestral stock split, giving rise to the _gebhardis_ subgroup and the _fumans_ subgroup. The former acquired the apomorphous condition of elytral pubescence restricted to the eighth interval, and then divided into _B. gebhardis_ with its apomorphous accessory setae on the mentum, and _B. galactoderus_ with its apomorphous slate-grey color of the elytra and milky color of the pronotum.

The ancestral stock of the remaining _fumans_ subgroup acquired the apomorphous conditions of a swollen shaft of the male median lobe, and infuscated sides of the venter.

This lineage divided into two sister stocks, the first of which had the apomorphous condition of accessory setae on the mentum and submentum. This stock subsequently split, forming _B. favicollis_, with its apomorphous large punctures of the pronotum, and an ancestral stock which subsequently split into _B. perplexus_ with its apomorphous non-twisted median lobe, and another ancestral stock. This latter stock subsequently divided, giving rise to _B. velutinus_ with its apomorphous dense pubescence, and _B. imperialensis_. The second ancestral stock without accessory setae on the mentum also split forming two sister species, _B. fumans_ with its apomorphous punctate anterior surface of the anterior tibia, and its median lobe with the basal bend rotated about 45 degress from the plane of the shaft, and _B. puberulus_. _B. puberulus_ is the most plesiomorphic of

the lineage, and is probably representative of the ancestral stock.

From the ancestral type of virga, there also arose the virga characteristic of the _cordicollis_ group. This type virga is slightly more complex than that of the _fumans_ group in that the apex has become somewhat truncated and a dorsal fin has developed distal to the gonopore. The ancestral _cordicollis_ lineage split giving rise to _B. mobilis_, with its apomorphous sulcate mentum, and another ancestral stock. This latter ancestral stock subsequently split again giving rise to _B. janthinipennis_ with its apomorphous narrow and acute male median lobe, and to still another ancestral stock, which subsequently split into two lineages. The first of these, the ancestor of the _cordicollis_ subgroup acquired the apomorphous condition of a longitudinal depression on the ventral surface of the shaft of the male median lobe. This ancestral lineage subsequently split giving rise to _B. ichabodopsis_, with its apomorphous broad stylus of the female ovipositor and the very elongate third antennal article, and to still another stock. This latter stock subsequently divided giving rise to _B. sublaevis_, with its apomorphous narrow stylus of the female ovipositor and its lack of elytral costae, and still another stock. This stock split giving rise to _B. cyanochroaticus_, with its apomorphous bright metallic blue elytra, and _B. cordicollis_. _B. cordicollis_ is the most plesiomorphic of the lineage, and is probably representative of the ancestral stock.

The second _cordicollis_ lineage gave rise to the _oxygonus_ subgroup with its apomorphous broadly rounded virgal apex. This lineage subsequently split giving rise to _B. vulcanoides_, with its apomorphous broad stylus of the female ovipositor and punctate anterior surface

of the anterior tibia, and an ancestral stock. This ancestral stock subsequently split giving rise to B. oxygonus, with its apomorphous elongate ligule of the shaft of the male genitalia and cylindrical antennal scape, and B. fulminatus. B. fulminatus is the most plesiomorphic of the lineage, and is probably representative of the ancestral stock.

The male (and therefore the virga) of the explosus group is unknown. This makes placing B. explosus into the scheme difficult, but because of the synapomorphies in relation to those of all other Neobrachinus species, I believe B. explosus is a rather recent lineage. The group has acquired the following apomorphous conditions: elytra strongly convex, shiny black; outer intervals only with pubescence; acute styli of the female ovipositor.

The last and probably most recently derived lineage of Neobrachinus in North America is the aabaaba group. The virga has become oriented transversely on the endophallus and very shortened. It has also become trilobate. The ancestral stock split giving rise to two sister species, B. aabaaba and B. sonorous. B. aabaaba acquired the apomorphous condition of an arcuate, narrow styli of the female ovipositor, while B. sonorous acquired the apomorphous condition of pale colored elytral epipleura, and completely pubescent proepipleura.

As can be seen from the data presented above, and in Section 4.5, many characteristics of the external morphology of Neobrachinus have arisen several times. If convergence in external characteristics was ruled out either by hypothesis or fact, and a phylogenetic arrangement was made utilizing only these external characteristics,

then the virgae and male median lobes would show convergence. In the hypothesis set forth in fig. 451, the characteristics listed in Table 5 have arisen more than once, in Neobrachinus of North and Middle America.

TABLE 5.

CONVERGENT CHARACTERS OF THE SPECIES OF NORTH AND MIDDLE AMERICAN Neobrachinus DERIVED FROM FIGURE 451.

CHARACTER AND CHARACTER STATE	NUMBER OF TIMES ARISEN
Infuscated palpi	2
Testaceous antennal article 2	2
Infuscated outer antennal articles	2
Testaceous antennal articles	2
Testaceous leg color	2
Single median mental pit	2
Elongate erect depression setae	2
Slate-colored elytra	3
Infuscated knees	3
Loss of lateral pronotal setae	3
Glabrous proepisterna	3
Elytral pubescence restricted to eighth interval	3
Elytral epipleura pale-colored	4
Reduction of wings	4
Infuscated antennal article 2	5

CHARACTER AND CHARACTER STATE	NUMBER OF TIMES ARISEN
Infuscated legs in part (other than knees)	5
Mesepisternum infuscated at sides	5
Abdominal sterna ferrugineous	5
Elytral pubescence restricted to intervals 6, 7, 8	6
Antennal articles 3 and 4 partially infuscated	7
Metepisternum ferrugineous	8
Proepipleura completely pubescent	8
Proepisterna completely pubescent	8
Sloped humeri	8
Highly elevated costae	9
Abdominal sterna infuscated at sides	12
Proepipleura pubescent both anteriorly and posteriorly	12
Elytral costae barely elevated	12
Median lobe with basal bend rotated 45° from plane of shaft	12
Metasternum infuscated at sides	13
Terga infuscated	13
Anterior tibia with anterior surface punctate	13
Accessory setae on mentum	15
Accessory setae on submentum	15
Antennal articles 3 and 4 completely infuscated	17

7.0 ZOOGEOGRAPHY

7.1 Introduction

In order to assess the movements of animals, we must use various clues to geographical histories of the animals we are discussing. Darlington (1957) discussed these clues and their shortcomings as part of his "working principles." Briefly, these clues are as follows:

1. Number clues, or information provided by counts of genera or species.—The highest concentration indicates the place of origin of the taxa in question. Recession and extinction of animals and differential latitudinal diversity sometimes mask the help number clues give us in this regard, but used critically this type of clue is very good.
2. Degree of differentiation.—Greater diversity and more endemism should occur where a taxon has been for a long time, rather than where it has just arrived. The masking effects of recession, extinction, and latitudinal diversity also apply here.
3. Extent of area.—The area occupied by a group of organisms increases directly with the group's age. The assumption here is that groups are continuously spreading. Of course, recession and extinction make this clue worthless by itself, but viewed in conjunction with other clues, it has some value.
4. Continuity of area.—Whether or not a group is relict.
5. Vicariance.—The distribution of sister groups.
6. Fossil clues.—The distribution of fossil remains of ancestors of the group under study.

With the exception of fossil clues (there are none), I have looked for places to apply these clues in considering the general patterns of bombardier beetle movements. In the more detailed study of North and Middle American Brachinus species, I have used numerical clues more extensively, especially methods proposed by Ball and Freitag (in Freitag, 1969). Section 7.2 deals with the general patterns of bombardier beetle distribution and past dispersal, while Section 7.3 deals with the details of Brachinus distribution patterns in North and Middle America. Because of the slightly different treatment resulting from more detailed knowledge of North and Middle American Brachinus species, I have separated these two sections.

7.2 General patterns of distribution

The Division Brachinida is represented in all major faunal regions of the world, with the exception of Oceania. Table 6 gives the distribution of the genera and subgenera in terms of the major faunal regions, and the island of Madagascar. Madagascar is generally treated as part of the Ethiopian Faunal Region, but because of the interesting diversity and great amount of endemism, I provide figures and separate considerations for that Island. For consistency it is also included as part of the Ethiopian Faunal Region, except when the two are directly compared.

TABLE 6.

DISTRIBUTION OF THE GENERA AND SUBGENERA OF THE DIVISION BRACHINIDA IN TERMS OF THE MAJOR FAUNAL REGIONS

	NEARCTIC	NEOTROPICAL	PALEARCTIC	ETHIOPIAN	ORIENTAL	AUSTRALIAN	MADAGASCAR
CREPIDOGASTER				X			X
TYRONIA				X	X		
BRACHYNILLUS				X			
CREPIDOLOMUS				-			X
CREPIDONELLUS				X			
CREPIDOGASTRILLUS				X			
CREPIDOGASTRINUS				X			
MASTAX			X	X	X		
PHEROPSOPHUS			X	X	X	X	X
STENAPTINUS				X	X		
APTINOMORPHUS				-			X
PHEROPSOPHIDIUS		X					
PROTOPHEROPSOPHUS		X					
APTINUS			X				
STYPHLOMERUS				X			
STYPHLOMERINUS			X	-	X		X
STYPHLODROMUS				X			
BRACHINUS			X				
METABRACHINUS				X			X
APLOA				X	X		

	NEARCTIC	NEOTROPICAL	PALEARCTIC	ETHIOPIAN	ORIENTAL	AUSTRALIAN	MADAGASCAR
BRACHINOAPTINUS			X				
APTINOMIMUS							X
CNECOSTOLUS			X				
NEOBRACHINUS	X	X			X		
APTINODERUS				X			
BRACHINULUS				X			
BRACHYNOLOMUS			X		X	X	
TOTAL	1	3	8	19	8	2	7
TOTAL ENDEMIC GROUPS	0	2	4	14	0	0	3
PERCENTAGE ENDEMIC	0	7.4	14.8	51.8	0	0	11.1

The genera and subgenera are considered equally, and for this analysis both are referred to as "groups." The greatest diversity in numbers of groups occurs in the Ethiopian Region south of the Sahara Desert with nineteen groups represented. The Palearctic and Oriental Regions have eight groups each. Madagascar alone has seven groups. The Neotropical Region has three groups, the Australian Region has two, and the Nearctic has only one.

Of the eight Palearctic groups, three are shared with the Ethiopian region. Of the eight Oriental groups, six are shared with the Ethiopian region. Both of the Australian groups are shared with the Oriental Region, and one with the Ethiopian Region. Of the three Neotropical groups, one is shared with the Nearctic. This

same shared group has a single known relict species extant in the Himalayan Mountains. The Palearctic and Oriental Regions share four groups. Of the seven Madagascan groups, three are shared with Africa and one is shared with the Oriental Region. A summary of comparisons between major faunal regions is presented in Table 6, and an Index of Dissimilarity for each region is presented in Tables 7 and 8. This Index is discussed in Section 7.32. Table 6 indicates the percentage of the entire group that is endemic to each major faunal region.

TABLE 7.

DISSIMILARITY VALUES AMONG FAUNAL REGIONS OF THE GROUPS OF THE DIVISION BRACHINIDA

FAUNAL REGIONS	STATISTICS	NEOTROPICAL	PALEARCTIC	ETHIOPIAN	ORIENTAL	AUSTRALIAN	MADAGASCAR
NEARCTIC	t[1]	4	9	20	9	2	8
	c[2]	1	0	0	1	0	0
	t - c	3	9	20	8	2	8
	$\frac{t-c}{t} \times 100$	75	100	100	88.8	100	100
NEOTROPICAL	t[1]		12	22	12	4	10
	c[2]		0	0	1	0	0
	t - c		12	22	11	4	10
	$\frac{t-c}{t} \times 100$		100	100	91.6	100	100
PALEARCTIC	t[1]			27	16	9	15
	c[2]			3	4	1	2
	t - c			24	12	8	13
	$\frac{t-c}{t} \times 100$			88.8	75	88.8	80

FAUNAL REGIONS	STATISTICS	NEOTROPICAL	PALEARCTIC	ETHIOPIAN	ORIENTAL	AUSTRALIAN	MADAGASCAR
ETHIOPIAN	t^1				27	20	26
	c^2				6	1	3
	$t - c$				21	19	23
	$\frac{t - c}{t} \times 100$				77.7	95	88.4
ORIENTAL	t^1					9	15
	c^2					2	2
	$t - c$					7	13
	$\frac{t - c}{t} \times 100$					76.6	80
AUSTRALIAN	t^1						8
	c^2						1
	$t - c$						7
	$\frac{t - c}{t} \times 100$						87.5

1 = Total number of groups in each pair of faunal regions.

2 = Number of groups in common between each pair of faunal regions.

TABLE 8.

INDEX OF DISSIMILARITY VALUES DETERMINED FROM TABLE 7.

AREA	ID
NEARCTIC FAUNAL REGION	564
NEOTROPICAL FAUNAL REGION	567
PALEARCTIC FAUNAL REGION	533
ETHIOPIAN FAUNAL REGION	555
ORIENTAL FAUNAL REGION	491
AUSTRALIAN FAUNAL REGION	549
MADAGASCAR	534

Table 9 presents the distribution of allopatric sister groups of the Division Brachinida. Three relationships seem evident: east-west vicariance, north-south vicariance, and mainland-island vicariance. The movements in terms of probable direction and general distance covered are indicated on maps (figs. 453-457). Figure 452 indicates possible centers of diversification.

TABLE 9.

DISTRIBUTION PATTERNS OF ALLOPATRIC SISTER GROUPS OF THE DIVISION BRACHINIDA

EAST - WEST RELATIONSHIPS

WESTERN VICAR		EASTERN VICAR	
NAME	CENTER	NAME	CENTER
Styphlodromus	Ethiopian	Styphlomerinus	Oriental—Madagascan
Cnecostolus	Transcaspian	Neobrachinus	New World

NORTH - SOUTH RELATIONSHIPS

NORTHERN VICAR		SOUTHERN VICAR	
NAME	CENTER	NAME	CENTER
Protopheropsophus	Mexico	Pheropsophidius	South America
Aptinus	Europe	Styphlomerus & allies	Ethiopia-Oriental
Brachinus	Europe	Metabrachinus	Ethiopian
Brachinoaptinus	Europe	Aploa	Ethiopian
Cnecostolus-Neobrachinus	Palearctic	Aptinomimus	Ethiopian

MAINLAND - ISLAND RELATIONSHIPS

MAINLAND VICAR		ISLAND VICAR	
NAME	CENTER	NAME	CENTER
Stenaptinus-Pheropsophus sensu stricto	Ethiopian	Aptinomorphus	Madagascan
Aptinoderus	Africa	Brachinulus	Isla Principe

7.21 Historical Zoogeography

This Section and the following one are a series of hypotheses to explain the distribution pattern described in the preceding Section.

I think the evidence clearly indicates that the origin of bombardier beetles took place on the African Continent, probably near the area where the equator is now, or slightly further south. The separation of the primitive ancestor of bombardier beetles from its sister group probably took place in the middle to late Cretaceous, and after Africa and South America separated.

The timing of the initial bombardier beetle migration is based on two events. The first is the necessity that ancestral Brachinus and Pheropsophidius members arrived in South America before that continent became isolated in the early Eocene. This is discussed more fully below. The second event is the timing of the break-up of Gondwanaland. Most studies describe this event as occurring before the middle Cretaceous. If primary bombardier beetle radiation had occurred before the continents separated, probably more groups would be present in South America, but there is a general paucity of bombardier beetle genera in South America and Australia. Further, the South American forms are not closely related to any African groups. Since the middle Cretaceous, Africa has remained an unsubmerged and rather stable piece of land (Moreau, 1952, 1966), and it is here that bombardier beetles began their dispersal.

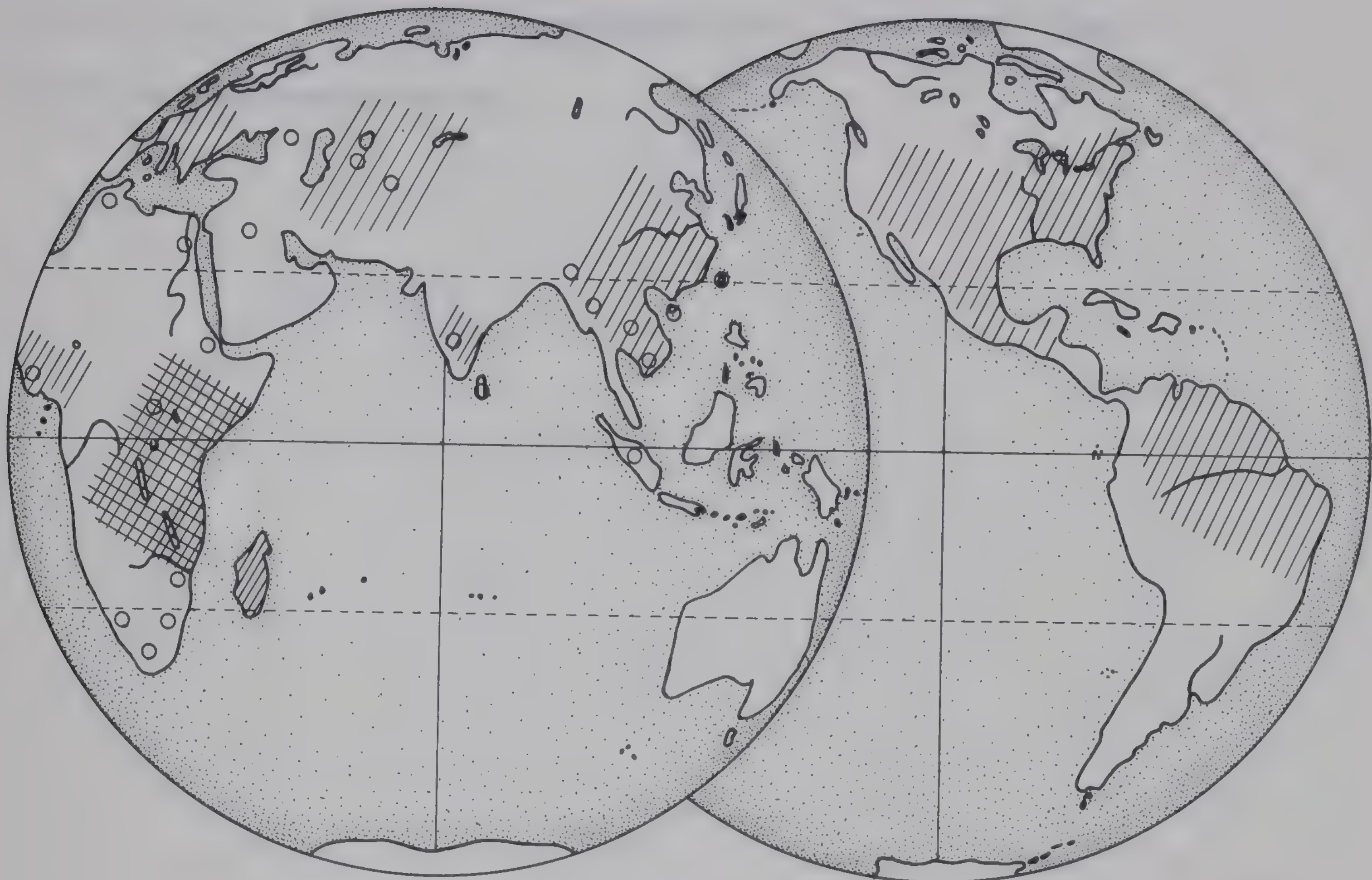
The primitive ancestor probably inhabited tropical savannahs as the crepidogastrines do today (Basilewsky, 1962a). From this center, radiation took place in at least five directions in the latter part of the Cretaceous. It was during this period that the ancestral lineage split into five stocks. However, these five stocks are not equal with the five major directions of dispersal. It was also during the late Cretaceous and early Paleocene that subtropical elements extended to at least 60° N (Axelrod, 1959). At this time these beetles were not restricted from northward migration by climatic conditions.

The five directions in which bombardier beetles made their prehistoric movements is indicated in figure 453. Various groups have evidently spread in the same directions but at different times. The pathways were probably diverse, but the directions were similar.

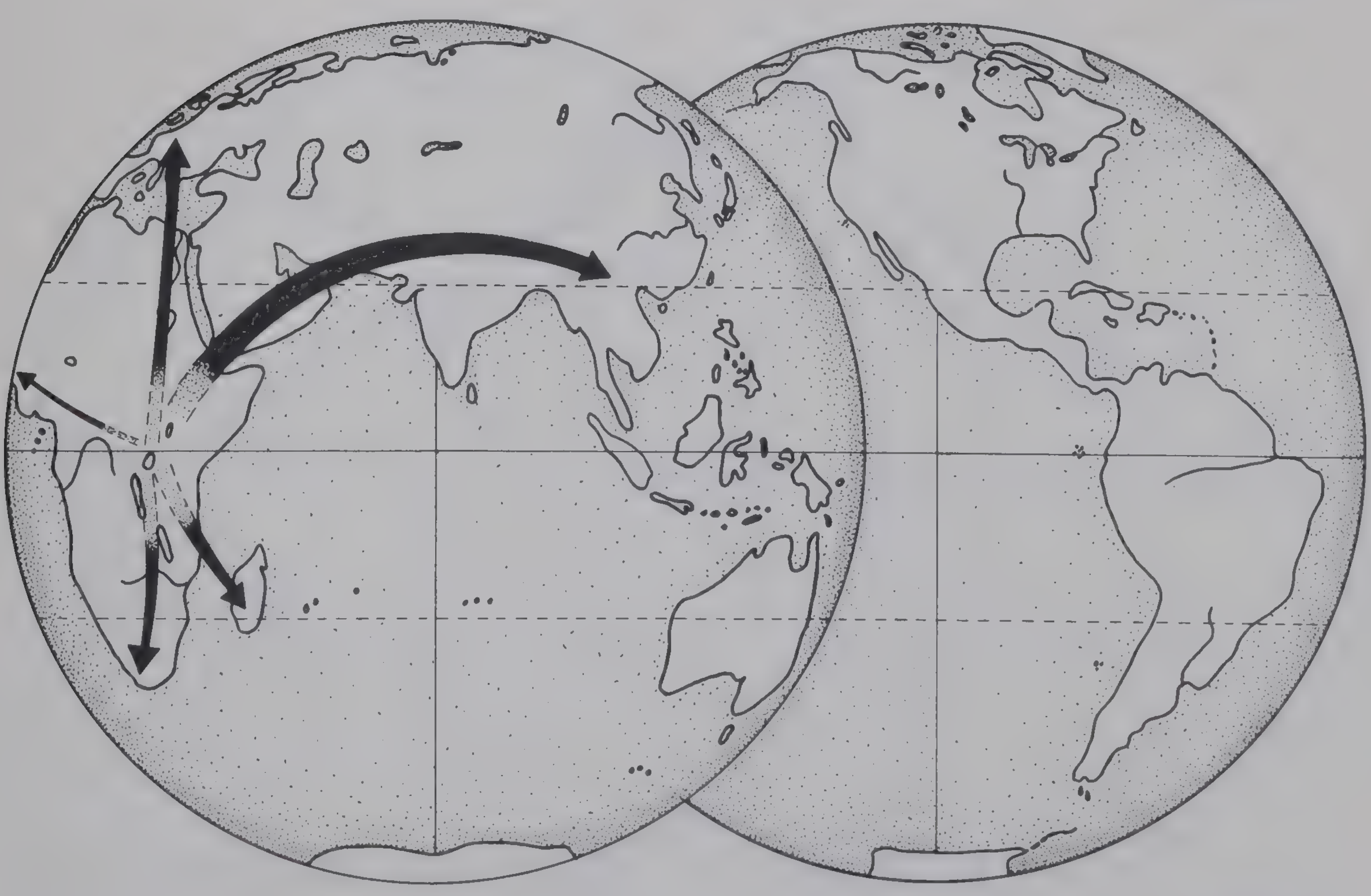
Those directions and possible pathways are discussed in conjunction with each of the five radiating stocks, below.

The crepidogastrines were at one time more widespread (fig. 454), but they have become extinct in all but southern India, and Ceylon (the latter two areas have one species each). The crepidogastrines are the most primitive of the Division Brachinida. All members are wingless and evidently the groups have been that way for a considerable time. No other group has undergone so extensive a reduction in flight components, therefore, I believe these beetles are similar in other respects to the ancestral bombardier beetles, although they have become apomorphous in numerous characteristics. I believe Jeannel (1949) is incorrect in his contention that the Indian-Madagascan-African distribution exhibited by these beetles indicates origin on the hypothetical landmass of southern India, Madagascar, and southern Africa called Lemuria. _Tyronia_, the genus represented in India, is the group that extends the furthest north in eastern Africa. Further, this group is not represented on Madagascar. There has probably been a withdrawal into Africa and India, with extinction in Arabia, during the development of intense desert conditions late in the Tertiary (Moreau, 1952). This would explain why _Tyronia_ species are very similar in India and Africa.

Fig. 452. Hypothetical primary (cross hatch) and secondary (single hatch) centers of radiation of the taxa of Division Brachinida, and distribution of extant species of the genus Mastax (open circles). Fig. 453. Hypothetical directions and routes of dispersal of the major taxa of the Division Brachinida.

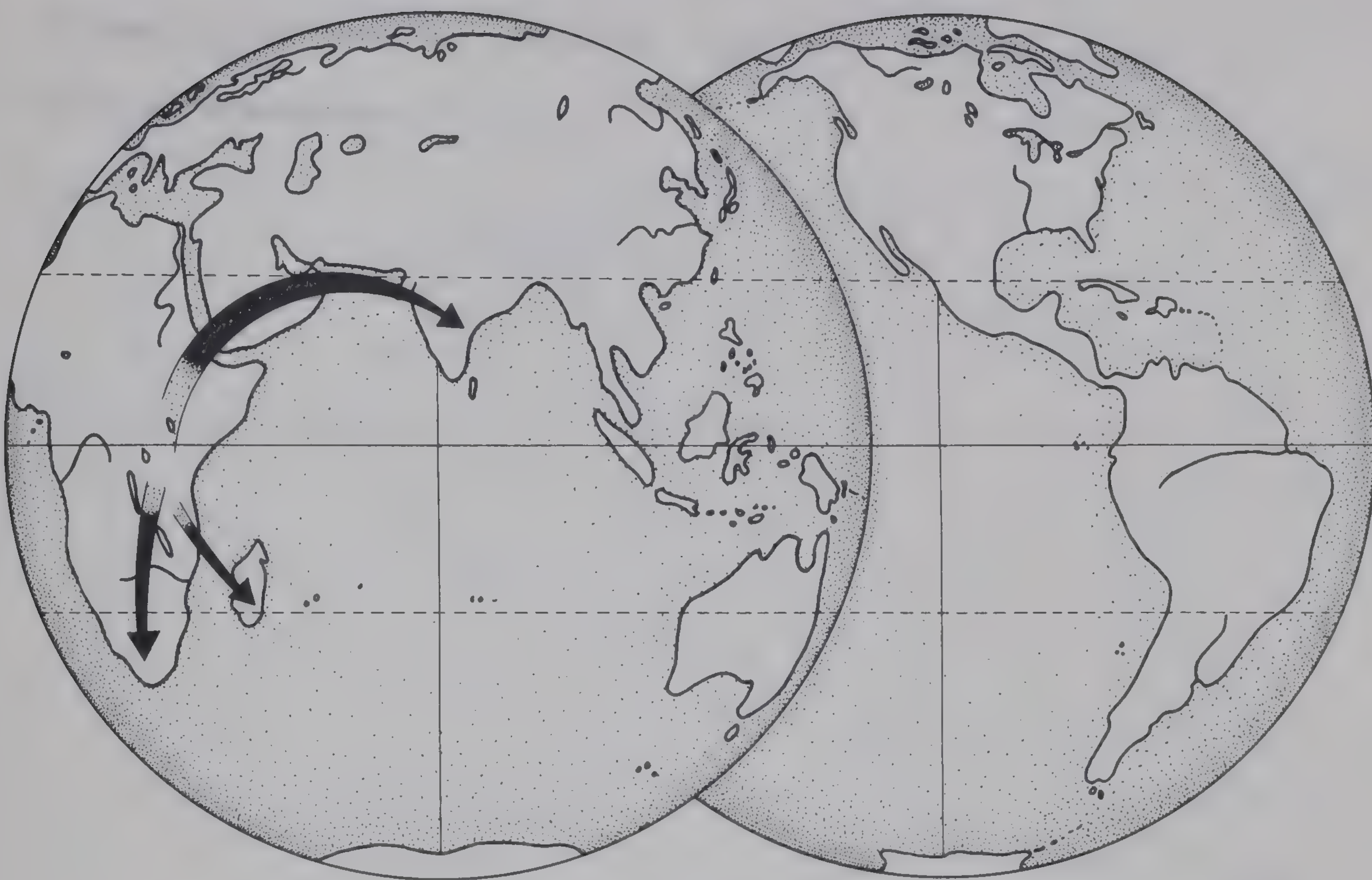


452

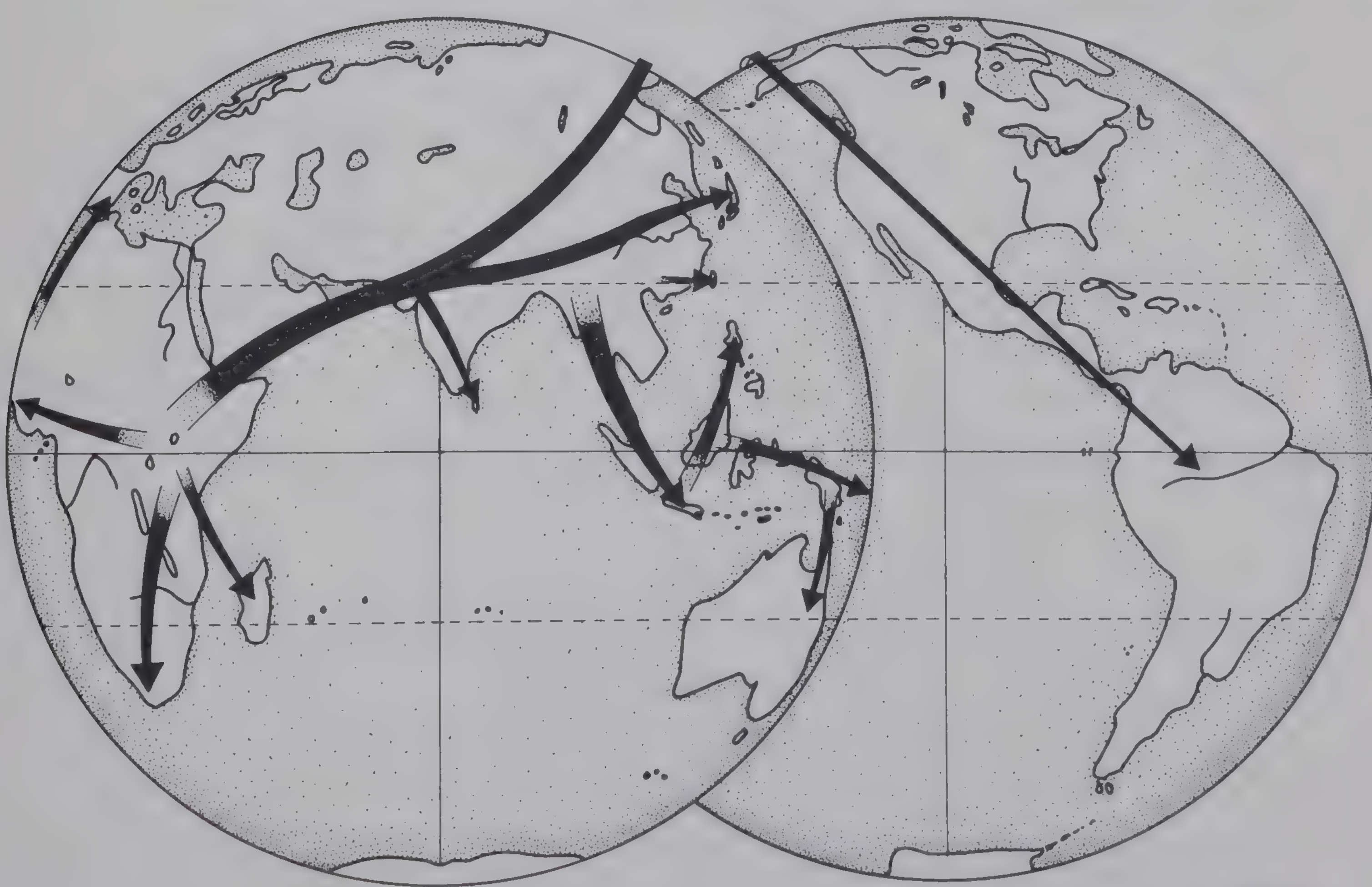


453

Fig. 454. Hypothetical directions and routes of dispersal of the taxa of the Tribe Crepidogastrini. Fig. 455. Same of Subtribe Pheropsophina.

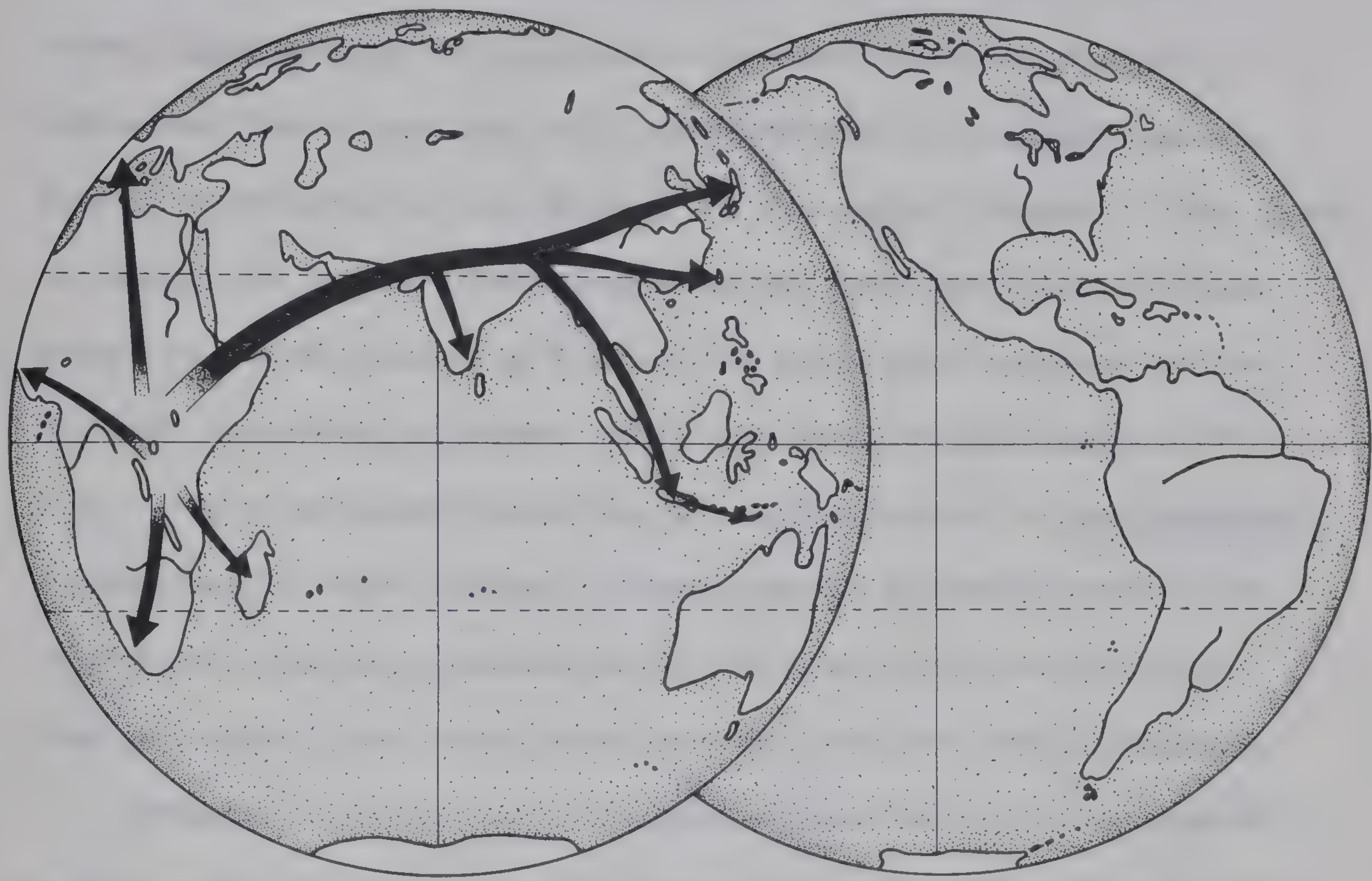


454

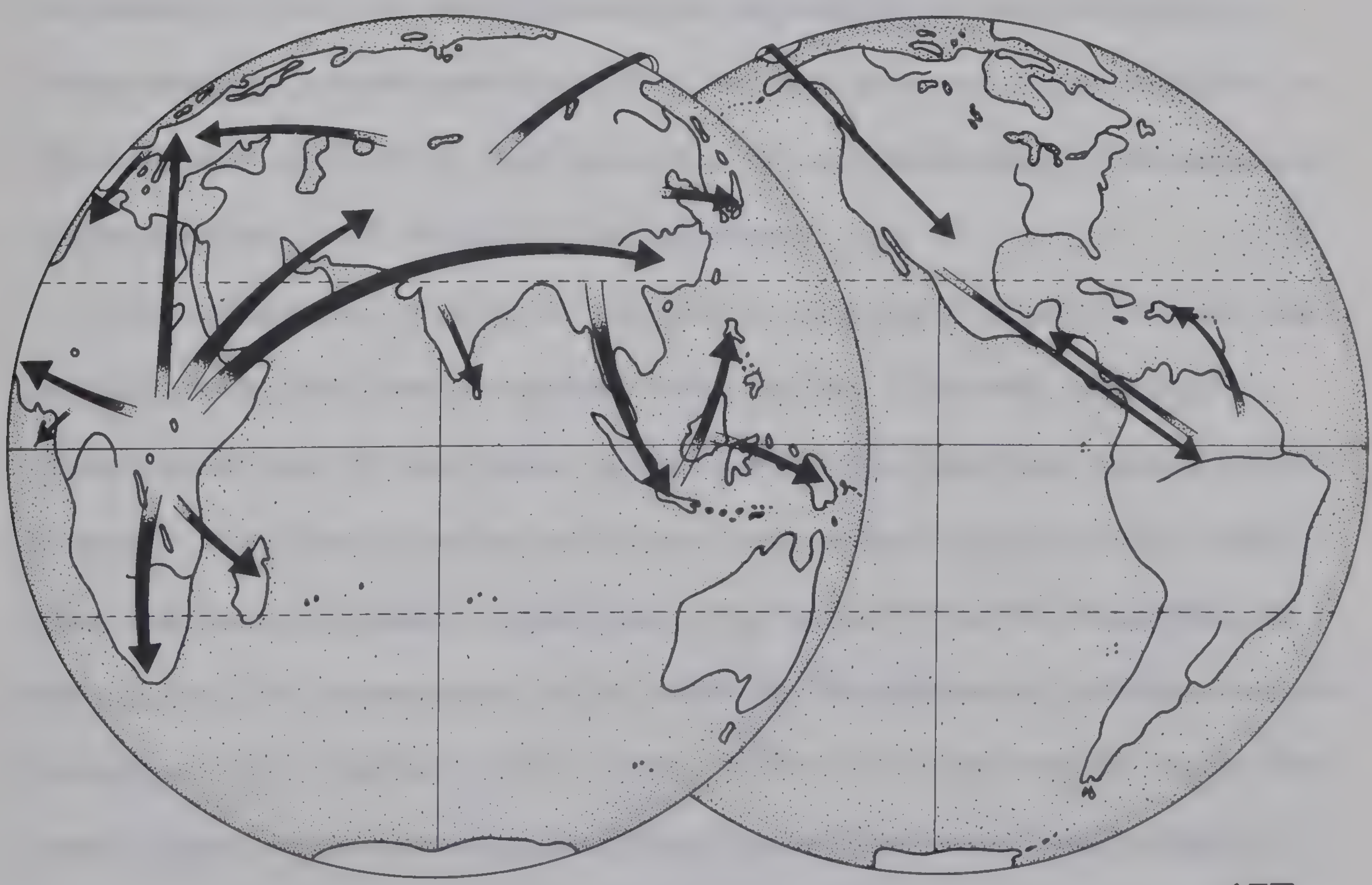


455

Fig. 456. Hypothetical directions and routes of dispersal of taxa of the Subtribe Aptinina. Fig. 457. Same of Subtribe Brachinina.



456



457

Two genera of Crepidogastrini occur on Madagascar. One of these, Crepidolomus, may represent the most primitive type of bombardier beetle species still in existence. Its members have a divided umbilicate series of setae in the eighth interval. This genus is endemic in southern Madagascar and may have been on the island before it became separated from Africa (near the beginning of the Tertiary according to Moreau, 1952; but see also Darlington, 1957: 519). The other genus occurring now on Madagascar is Crepidogaster, represented by three species. These species probably reached the island more recently, across water. However, Basilewsky (1959) does not state their relationships and I have not seen specimens.

Briefly, the history of the crepidogastrines has been one of early expansion at least to the edges of the Oriental Region, followed by a period of differential extinction. More recently the group has become restricted to the southern and eastern parts of Africa, with only a few phylogenetic relicts occurring on Madagascar (four species) and in India (two species).

The ancestral lineage of Mastacina must have separated from its sister group, the Pheropsophina, very early. The many aberrant characteristics of this small group indicate a long and independent history. The distribution pattern of the extant species (fig. 452) also indicates isolation long ago. The pattern can be described as widespread, but consisting of at least 12 disconnected endemic pockets. Because of this pattern, it is very difficult to determine where the group arose. Its sister group, the Pheropsophina, probably arose in Africa, but the masticine-pheropsophine ancestral lineage may have been widespread. Mastax has as many species in Asia as in Africa.

In order to judge where Masticina arose and how it dispersed, a thorough study of relationships of the species of Mastax must be undertaken. Faunal studies presently available should expedite this task, for example see Andrewes (1924, 1930), Bates (1892), Jedlička (1963), Liebke (1934), Peringuey (1885, 1896), and Schmidt-Goebel (1846).

The subtribe Masticina is widespread, but the discontinuous pattern does not provide clues to past movements.

The species of Pheropsophina display a very complex distribution pattern (fig. 455). The most pleisomorphic species are now found only in southern Mexico and South America, but the group must have originated in Africa. Probably an original radiation of an ancestral Pheropsophidius group (with costate elytra like all other bombardier beetles) occurred in late Cretaceous or very early Tertiary times. This group was widespread and occurred in the eastern part of Asia. One species invaded the New World via the Bering Land Bridge. This probably occurred in the Paleocene when tropical conditions extended north nearly to 60° N. They continued to spread southward and crossed into South America. The withdrawal of tropical conditions, and the closing of the Central American Land Bridge to South America isolated this primitive stock on both the north and south side of the bridge (but see also Hershkovitz, 1966). In the vast South American tropics they underwent secondary radiation, resulting in the extant species of Pheropsophidius (sensu stricto). In Middle America, they withdrew to the southern slopes of the Sierra Madre del Sur, finally evolving in to the wingless species of Protopheropsophus.

Meanwhile, in Africa, another more successful lineage arose with

carinate costae on the elytra. An early member of this lineage invaded Madagascar and radiated there in isolation (Aptinomorphus). The rest of the lineage radiated and ultimately displaced the ancient Pheropsophidius lineage in Africa and Asia. By the time this wave reached the eastern part of Asia, the tropics had receded from the Beringia Region, thus there was no chance for an invasion of the New World (even if the Bering Bridge was still in existence). Members of this second lineage (Stenaptinus) still exist as far east as Formosa, the Philippines, and New Guinea. These beetles subsequently became wingless and now show an endemic pattern, (except in Africa, where they are widespread in the tropics). Finally, a third wave, the Pheropsophus (sensu stricto) lineage, overtook this second wave. It shows a continuous pattern of distribution throughout the tropics from west Africa to the Solomon Islands in the Pacific. Most members are winged and presumably highly vagile. These forms have moved into many continental islands and have occupied Madagascar. Species now living on the Comoro Islands indicate that those islands may have been the route by which bombardier beetles have invaded Madagascar (see also Darlington, 1957:520). The movement onto Madagascar, the Japanese Archipelago, Formosa, the Philippines, and other islands may have occurred more than once, since some of the islandic species are endemic, yet others are widespread on the Asian mainland. This is also true of the Indonesian fauna and the species of New Guinea. There has been at least one recent movement down the Malay Archipelago, engulfing most of the islands, and continuing to Australia. This movement probably took place in the Pleistocene when the seas were lower and the gaps between islands were narrower. The

fact that one species reached Australia but has thus far diverged into only "varieties" indicates that this movement was rather recent.

Briefly, the history of Subtribe Pheropsophina has been one of wave after wave of more apormorphous groups, arising in Africa and spreading eastward into the Oriental Region. The first wave invaded the New World and is now confined to the Neotropical Region. The two successive waves have been successful island-hoppers, at least when water gaps were not too great. The Stenaptinus lineage has withdrawn into geographically isolated pockets, and the members have become flightless. The third wave is still dispersing, or was dispersing as recently as the Pleistocene Epoch.

I suspect that these beetles also may be susceptible to dispersal by human agencies. The larvae of at least one species are ectoparasitoids on mole cricket egg clutches and occur in paddy fields and other agricultural lands (Habu, 1967). Plants transported with soil may possibly carry these larvae or adults and their hosts into new areas.

The members of Aptinina probably had a very early dispersal into southern Europe from Africa (fig. 456). This early lineage subsequently became isolated and underwent changes common to mountain isolates (Darlington, 1943), as the Aptinus stock became fragmented in the changing mountain systems of southern Europe (Povolny, 1966). They became wingless and most became very darkly colored overall. (One species, which still occupies the lowlands has members with a red prothorax, and the males have the median lobe contorted to the left.

Concurrently, the vicariant sister group underwent considerable

change and converged with the members of Brachinus in Africa. Since the original exchange, no dispersal of Aptinus, or Styphlomerus and its allies has occurred across the Mediterranean area. Styphlomerus, the most primitive of this African lineage, has either remained in Africa, or has withdrawn into Africa as the more advanced Styphlomerinus dispersed. This derived group (Styphlomerinus) has spread from Africa in two directions (fig. 456), extending south to Madagascar and east to Japan and the Malay Archipelago. Still another group emerged in Africa, probably from a Styphlomerinus-like ancestor, and subsequently displaced Styphlomerinus in Africa. This group, the Styphlodromus, are now still within the primary center of bombardier beetle radiation.

Briefly, the history of the Aptinina has been one of early dispersal into Europe, subsequent isolation of both groups, and secondary dispersal of the African lineage. During this secondary dispersal, some species have island-hopped at least onto continental islands.

The members of Brachinina differentiated sufficiently long ago for one stock to have entered the New World via the Bering Land Bridge, when it was still tropical or warm temperate. This probably occurred about the same time that the Pheropsophidius ancestral lineage invaded the New World. The primary radiation from Africa must therefore have occurred sometime in the late Cretaceous or early Tertiary. Remnants of this early group (Aptinoderus and Brachinulus) are presently found in southern-most Africa and on the west African Isle of Principe, respectively.

These two groups represent the earliest radiation of Brachinina,

and have probably been isolated and pushed to the periphery (fig. 457) of the original range by successive groups. The first of these successive groups was probably the "asymmetrical" lineage, which gave rise to Brachinus (sensu stricto), Brachynolomus, and Metabrachinus. All three arose in middle Africa and radiated north, north and east, and south, respectively. Brachynolomus is widespread from Europe to New Guinea, while the range of Brachinus (sensu stricto) is narrow and confined to Europe. Both groups have subsequently invaded northwestern Africa, probably during the Pleistocene, since the species there are the same as in Europe. Both groups were replaced in Africa by the southern vicar, Metabrachinus. This group has invaded Madagascar at least once. The members of Brachynolomus that reached the Malay Archipelago probably reached New Guinea recently, because B. papua Darlington is hardly (if at all) different from B. bigutticeps Chaudoir of Java (Darlington, 1968). This may not be true of the Philippine species, as I have not seen mainland representatives of Brachinus luzonicus Chaudoir.

Concurrently with the origin and dispersal of the "asymmetrical" ancestral stock the second group referred to as the "symmetrical" lineage, arose in the primary center. An early offshoot of this lineage spread north into the area adjacent to the Caspian Sea, while another invaded Madagascar. Yet a third group of this symmetrical lineage radiated into many regions. One of these latter forms Brachinoaptinus, moved north into Europe, and subsequently invaded northwest Africa from there. It probably did so before Brachinus (sensu stricto) and Brachynolomus, since there are many differentiated species found only in this area, and all members of this lineage are

wingless and highly endemic. Another symmetrical form, Aploa, moved to the periphery of the African continent, and east at least to India. These species appear to be adapted to desert conditions and probably have dispersed since the desert areas expanded during the late Tertiary. Various other lineages probably arose from this stock, but the relationships are still unclear (see Section 6). The early offshoot that spread into the region adjacent to the Caspian Sea underwent secondary radiation into Cnecostolus and Neobrachinus, and subsequently spread eastward and westward, respectively. At least one species of Cnecostolus spread to Europe, while another, the ancestral Neobrachinus, invaded the New World via the Bering Land Bridge. Once in the New World, extensive radiation occurred with at least one species (probably more) reaching South America. Subsequently, the Bering Land Bridge became broken or the climate changed, and no further exchange took place. Without more study of the Asian species of Brachinus, it is impossible to state whether B. dryas of Sikkim is a phylogenetic relict or a part of Subgenus Neobrachinus that moved back across Beringia, after differentiating in the New World. Also the route to South America became broken and two brachinine stocks were isolated (Brachinus and Pheropsophidius), and became adapted to Neotropical conditions. In the North, members of these groups also existed, becoming temperate and desert types. The details of these patterns are discussed below.

Briefly, the history of the Brachinina has been very complex, and definite conclusions cannot be reached until these unnamed and unstudied African and Indian lineages are more fully studied.

In summary, the bombardier beetles have radiated from middle

Africa in five directions. To the west each group sent a few species along the tropical west coast. One definitely endemic genus is found on Isla Principe in the Gulf of Guinea. At least one unnamed *Brachinus* lineage occurs in this area. Further south, primitive groups survived and became isolated. Madagascar has received members of seven groups, and is a center of secondary radiation on a small scale. One group spread to Europe from the region of the Caspian Sea, and four groups spread northward, including three lineages of *Brachinus* and the ancestral *Aptinus*. The three *Brachinus* lineages subsequently invaded the northwest coast of Africa.

The region of the Caspian Sea acted as a staging area preceding movements into the New World for *Neobrachinus*, and movement into Europe for *Cnecostolus*.

In general, all groups have spread at one time or another to the east. Very early the Crepidogastrini spread from Africa as far east as India and then withdrew, isolating some species in southern India. All other groups have spread eastward, three of these to Japan, and all four to the Malay Archipelago, two as far east as New Guinea, and one onto Australia. Two groups invaded the New World via the Bering Land Bridge sometime before the Eocene. Both groups spread to South America and became isolated on both sides of the Middle American Seaway until the Pliocene. At that time, southern groups began spreading northward, and northern groups possibly spread southward.

7.22 Evidence of barriers

Movement of animals can be restricted or halted by at least three

kinds of barriers. The first kind of barrier is a physical obstruction, such as large bodies of water or mountain ranges. The second kind of barrier is one of unsuitable climate. The third type might be called an ecological barrier (including biological factors such as competition, etc.) which prevents successful establishment of species beyond certain delineated regions. The patterns of movements displayed by bombardier beetles indicates that barriers have played an important role in their dispersal. In this Section, I wish to analyze those movements in terms of the barriers indicated by studies of present and past geological and climatic conditions. I have consulted the following references: Andrewes (1929), Axelrod (1959), Ball (1959), Basilewsky (1962a), Cohn (1965), Darlington (1957, 1965), Espenshade (1964), Halffter (1964), Moreau (1952, 1966), Hershkovitz (1966), Paulian (1961), Povolny (1966), Romer (1966), Savage (1967), Simpson (1947), and Woodford (1965).

Eighteen groups have dispersed from Africa during the history of the bombardier beetles. Movement to the north has been relatively slight, only four groups having spread into Europe from Africa. To me this indicates that an intensive and long-lasting barrier has been present. The two possible barriers are the Tethys Sea, early in the Tertiary, and the climatic conditions during the late Tertiary and Quaternary Epochs. Three of the four European groups are now confined to temperate conditions, while the fourth is wide-ranging both in temperate and tropical regions. These groups were probably able to cross the Tethys via temporary land connections early in the Tertiary and became adapted to temperate conditions later. The relatively small number of species and the general lack of diversity in the

European fauna suggests that bombardier beetles have not been as successful in Europe as elsewhere. This may be a direct result of climate, aided by the slowness with which tropical groups adapt themselves to temperate climates.

Movement to the east has been more extensive, for nine groups have spread in this direction. This indicates some interruption of spread, but not nearly as severe as that which limited spread toward the north. Physical barriers have probably been more important between the Ethiopian Region and the Oriental Region than have climatic barriers. Geological evidence does not admit connections between Asia and Africa until the late Miocene, but birds, plants, and bombardier beetles indicate that some exchange must have occurred. Temporary and partial connections would explain why so few bombardier beetles have spread eastward early in the Tertiary.

The lineages that spread to the Oriental Region have all dispersed continuously over landmasses, with no barriers to stop them. However, the water gaps between the mainland and the Oriental islands have acted as partial barriers. No group has crossed extensive water barriers. The movement down the Malay Archipelago occurred at least twice, but both invasions probably occurred when sea level was lower and the water gaps narrower. This is substantiated by the pattern of distribution.

Movement to the New World occurred only after the climatic barrier in Beringia ameliorated during the early Tertiary as described below.

Minor barriers between species of Neobrachinus are discussed in Section 7.3. However, within the New World, the major barrier has

been the water gap which existed in the past, between Central and South America. The patterns of distribution of both Neobrachinus and Pheropsophidius indicate that this barrier was in existence throughout a major part of the Tertiary (but see also Hershkovitz, 1966).

Movement to Madagascar from Africa seems to have occurred throughout the history of the bombardier beetles and therefore has occurred over water, at least in part. Madagascar has seven endemic groups, but it also has species of African groups that are hardly differentiated. One species of Pheropsophus (sensu stricto) occurs on Madagascar and some of the Comoro Islands. This may have been the route by which bombardier beetles have crossed into Madagascar. Movement of ancient ancestral lineages to Madagascar may have been direct, however, if that island was ever actually connected with Africa.

Movement into southern Africa has been uninterrupted, with fourteen out of eighteen groups moving in this direction from their Central African origin. The southern flow of bombardier beetles probably has been affected only by shifting climatic zones and surface relief changes.

Movement into western Africa has been very slight, with only six out of eighteen groups moving in this direction. This indicates that efficient barriers have always existed in the center of the African continent. Evidence indicates that the East African mountain systems and the arid belt west of those mountains have barred movements between lowland forests of the east and west (Moreau, 1952). Several authors indicate this must have existed at least since mid-Pleistocene, and possibly much longer. The patterns of distribution

of bombardier beetles indicate that here have been extensive mid-African barriers, at least since the early Tertiary.

The major limiting factor in the dispersal of bombardier beetles has evidently been climatic. Only six of twenty-seven groups have become adapted to temperate conditions in the north. Four of these are restricted to the temperate zone, while the other two still have tropical representatives. Physical barriers have also played an important role in the dispersal of these beetles, particularly between continents.

7.3 Distribution patterns of North and Middle American Brachinus

7.31 Introduction

The genus Brachinus is represented in all parts of North and Middle America south of 52° N. The present pattern of distribution is the result of climatic and physiographic changes throughout most of the Tertiary and Quaternary, roughly 60 to 70 million years. In the more northern latitudes of this area, the Pleistocene glaciations have probably affected these distribution patterns. In the southern latitudes, Pleistocene glaciations have probably indirectly affected the patterns in at least three ways: by changing drainage systems; by changing climatic patterns; and by pushing northern groups south into the habitats of the southern groups, and therefore into at least partial competition with these southern groups.

Much has been written about climatic and physiographic changes, and these changes in relation to animal distributions in North and

Middle America. The following references have been consulted: Axelrod (1948, 1950, 1958, 1959); Ball (1956, 1959); Cohn (1965); Espenshade (1964); Graham (1964); Halffter (1964); King (1958, 1959); MacGinitie (1958); Martin (1958); Martin and Mehringer (1965); Ross (1965); and Whitehead (1965). Ball and Freitag (in Freitag, 1969), and Larson (1969) have briefly summarized the climatic and physiographic changes in relation to ground beetle movements.

7.32 Methods and general patterns

This Section quantifies the data on the zoogeography of recent bombardier beetles in North and Middle America. The numbers of species in different parts of the area present various patterns and it is the object of this Section to discover possible factors influencing these patterns. I have attempted to parallel this Section with the zoogeographical analysis of *Evarthrus* by Ball and Freitag (in Freitag, 1969) in order to test their methods in a comparison with highly vagile bombardier beetles (*Evarthrus* are all flightless). I think this comparison is a valid one because both *Brachinus* and *Evarthrus* are ground beetles and general omnivores, and are more or less taxa of equal rank.

In Section 4.5 the species descriptions are accompanied by dot maps. Overlaying these dot maps with a grid map (fig. 458) provided a means of obtaining total numbers of species in each grid quadrant. The grid map of North and Middle America is divided into 5° intervals, both longitudinally and latitudinally. The number in each grid represents the total number of species recorded from that area, as determined by the dot maps. Based on methods proposed by

Ball and Freitag, (in Freitag, 1969), I have determined the "Total Interval Values" (TIV) for each 5^{o} interval of longitude and latitude (fig. 458 and table 10). Because of the greater extent of coastline involved in the distribution of Subgenus Neobrachinus compared with that of Evarthrus studied by Ball and Freitag, I have used an "Average Landmass 5^{o} Interval Value" (ALIV), rather than just an "Average 5^{o} Interval Value." The "Average Landmass Value" was determined by dividing the "Total Interval Value" (number of species in each 5^{o} interval, both horizontally and vertically) by the number of intervals. The number of "landmass intervals" was adjusted at the coasts by approximating the amount of land in the 5^{o} x 5^{o} interval to the nearest 25%.

The primary information derived from this grid map indicates that the number of species is maximum in southern Texas, slightly less in the American Southwest and Northern Mexico, and from those areas, it decreases in all directions, but subsequently increases slightly in Florida and the Great Lakes Region. The great reduction in numbers of species known from Central America is probably due to inadequate collecting in the area. The paucity of species from the Great Basin and Rocky Mountain region is less easily explained.

The alkali sinks of the Basin and Range Province of the Great Basin provide the aquatic habitats. Since most (if not all Brachinus in North and Middle America are confined to water-side habitats, the high percentage of soil alkali may be restrictive. The fact that the few species occurring in the Great Basin are the most widespread in North America, indicates that these beetles are probably more tolerant to various conditions, and may be able to tolerate alkalinity.

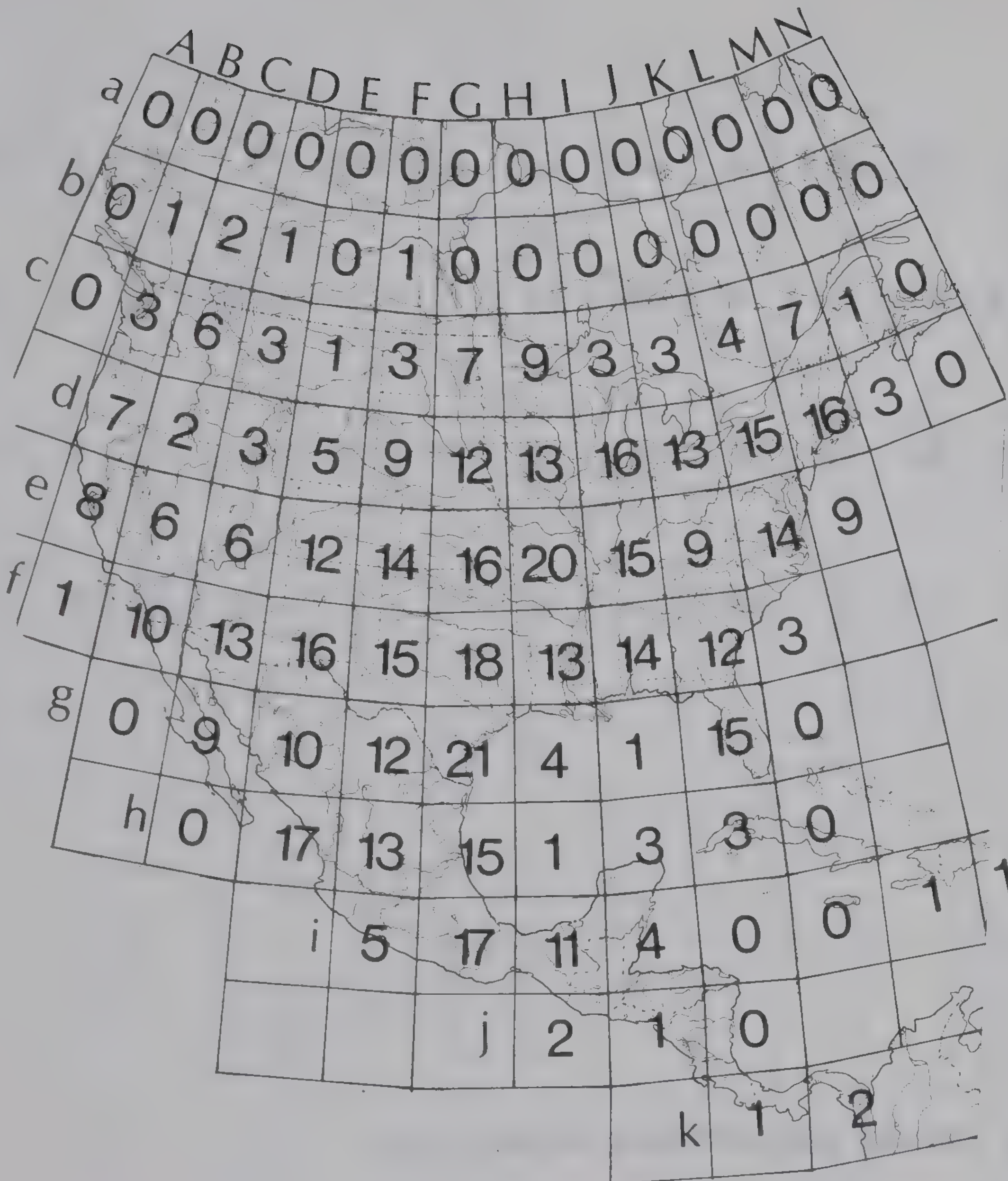
Brachinus populations in North and Middle America do not live at higher elevations in mountains. The few species within 5,000 to 7,000 feet elevation in New Mexico, Arizona, and Mexico are living in subdesert conditions on high plateaus. The Rocky Mountains provide a partial barrier, probably because they lack suitable conditions in which these beetles can live. This is apparently true of the southern Appalachian Mountains also, since only two species occur in these old mountains, both of which may not be restricted to waterside habitats.

The general reduction of species toward the north is perhaps due to Pleistocene glaciation and its effects on climate (Howden, 1969), however it should be noted that nowhere in the world do bombardier beetles extend very far beyond warm temperate conditions.

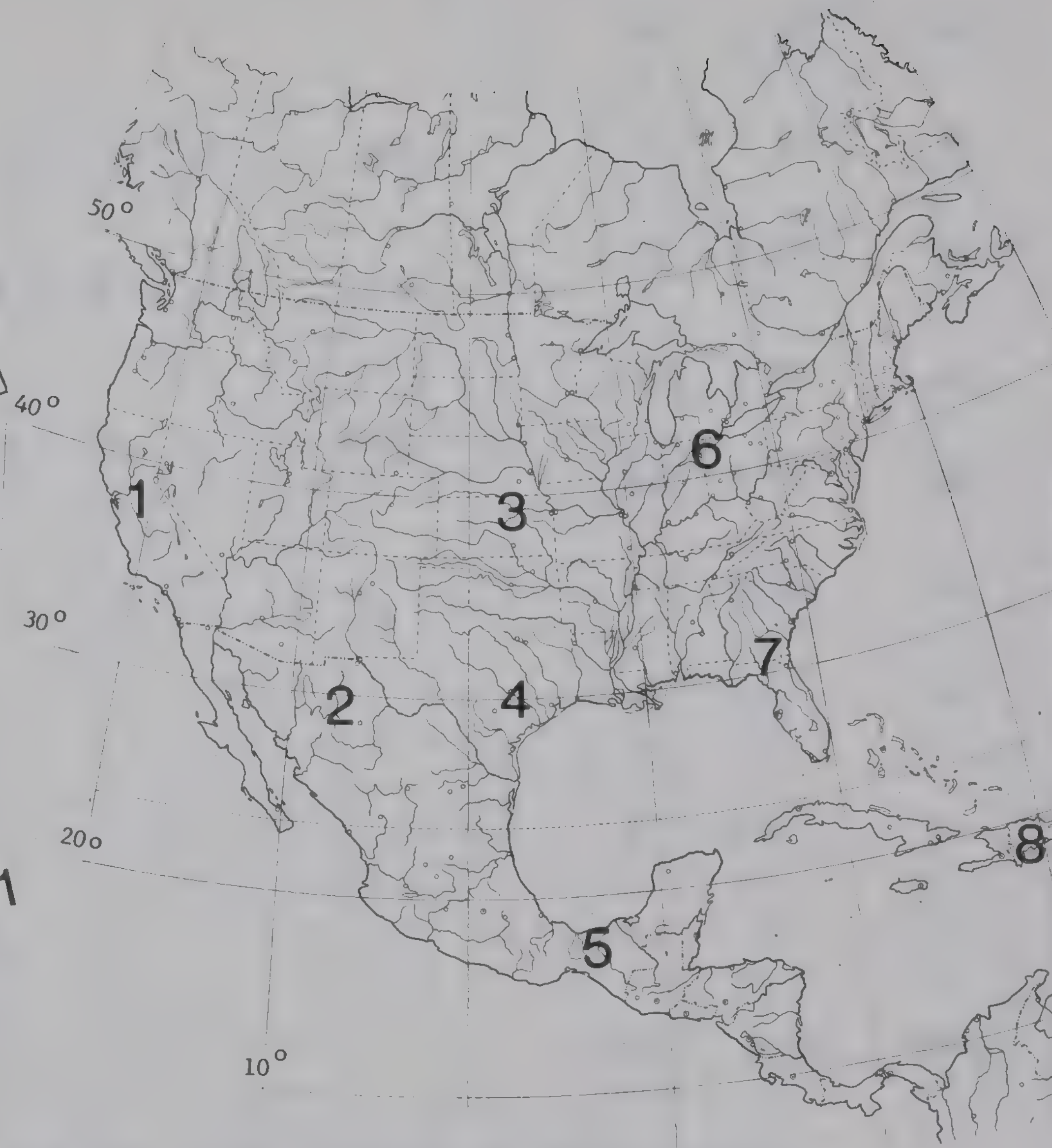
The general east-west pattern is one of reduction in both directions. from the American Southwest. The east-west lateral asymmetry, with average species densities higher in the west, that Simpson (1964) shows for mammals is reversed in bombardier beetles. Numbers of breeding land birds is also much higher in the west (Robbins, et al 1966, from MacArthur and Wilson, 1967). High numbers in the west for both birds and mammals can certainly be correlated with diverse topographic relief (as Simpson, 1964, states for mammals), but it is just this relief that eliminates "lowland" bombardier beetles from existing in these areas.

Secondary information derived from the grid map is used in determining the overall range of Neobrachinus species, the centers of concentration, and an analysis of vicariance.

Fig. 458. The number of species of Brachinus in 5° intervals of longitude and latitude. Capital and lower case letters designate 5° intervals used in Table 10. Fig. 459. Centers of concentration of the species of the genus Brachinus in North and Middle America.


A B C D E F G H I J K L M N
a 0 0 0 0 0 0 0 0 0 0 0 0 0 0
b 0 1 2 1 0 1 0 0 0 0 0 0 0 0
c 0 3 6 3 1 3 7 9 3 3 4 7 1 0
d 7 2 3 5 9 12 13 16 13 15 16 3 0
e 8 6 6 12 14 16 20 15 9 14 9
f 1 10 13 16 15 18 13 14 12 3
g 0 9 10 12 21 4 1 15 0
h 0 17 13 15 1 3 3 0
i 5 17 11 4 0 0 1 1
j 2 1 0
k 1 2

458


50°
40°
30°
20°
10°
1
2
3
4
5
6
7
8

459

TABLE 10.

TOTAL NUMBER OF SPECIES, ALIV, AND TIV VALUES DERIVED FROM FIGURE 458.

^{o}N	#spp.	ALIV	TIV
a	0	0	0
b	3	1.2	5
c	16	4.5	50
d	26	10.8	114
e	39	13.5	129
f	39	15.3	115
g	38	20.5	72
h	28	26	52
i	20	16.7	39
j	2	4	3
k	2	4	3

^{o}N	A	B	C	D	E	F	G	H	I	J	K	L	M	N
#spp.	0	9	13	19	32	32	45	33	29	24	21	17	4	0
ALIV	0	6.6	5.8	6.5	11.6	9.8	21.2	15.3	11.2	19	10.8	11.5	5	0
TIV	0	20	26	35	61	72	106	73	57	56	38	33	5	0

It is interesting to compare the data given by Ball and Freitag (in Freitag, 1969) for the "flightless" members of the genus Evarthrus with that given below for the "highly vagile" members of most Neobrachinus species.

Table 11 expresses the Index of Range Extent, determined by a linear measurement between the two furthest localities on the dot maps. The four species known from only one locality (B. capnicus, B. explosus, B. ichabodopsis, and B. mobilis) were omitted from this analysis. If the species are divided into three general categories, 35 per cent of the species have ranges less than 1,000 miles in extent, 39 per cent have ranges between 1,001 and 2,000 miles and 19 per cent have ranges of more than 2,000 miles in extent. Evarthrus, on the contrary has nearly 50 per cent of its species ranges extending less than 500 miles, and only 11 per cent of the Brachinus species have ranges covering less than 500 lineal miles.

The restricted ranges of Evarthrus species suggested to Ball and Freitag that either (1) barriers to dispersal existed, or (2) that many of the ranges of the Evarthrus species are less extensive than they used to be, and the species are surviving as relics. In Brachinus only 11 per cent of the species fit into these categories. The extensive ranges of 89 per cent of Brachinus species in North and Middle America are probably less restricted by physical barriers than they are by broad climatic zones. The relationships between broad climatic zones and the centers of concentration discussed below are indicated in figure 459. The climatic zones are discussed in Section 7.33.

TABLE 11.

FREQUENCY DISTRIBUTION OF MAXIMUM LINEAR EXTENT OF GEOGRAPHICAL RANGE IN MILES OF THE SPECIES OF *Brachinus* OF NORTH AND MIDDLE AMERICA

CLASS	NUMBER	PERCENTAGE
2,501 - 2,750	5	
2,251 - 2,500	5	19%
2,001 - 2,250	2	
1,751 - 2,000	9	
1,501 - 1,750	2	39%
1,251 - 1,500	8	
1,001 - 1,250	5	
751 - 1,000	11	
501 - 750	4	35%
251 - 500	3	
1 - 250	4	
1 locality only	4	6%

TABLE 12.

CENTERS OF CONCENTRATION OF THE SPECIES OF *Brachinus*

CENTER NUMBER	LIMITS
1	Pacific coast states, in California west of Sierra Nevada crest, north of Tehachapi crest.
2	Southwestern deserts (including southern California south of the Tehachapi), Arizona, New Mexico, western Texas west of 100° W, and northwestern Mexico including Baja California del Norte and the Mexican Highplain.
3	Great Plains between 90° W and 105° W, 45° N, and 35° N.
4	Central and Southern Texas
5	Southern Mexico around the Bahia de Compeche and eastern Yucatan.
6	Northeastern United States and southern Great Lakes Region.
7	Southeastern United States east of the Mississippi River, south of 35° N.
8	Greater Antilles

TABLE 13.

DISTRIBUTION OF THE SPECIES OF Brachinus IN RELATION TO THE CENTERS OF CONCENTRATION

NAME OF SPECIES	CENTER NUMBER							
	1	2	3	4	5	6	7	8
americanus			X	X		X	X	
alexiguus			X	X				
microamericanus			X					
capnicus							X	
texanus			X	X		X	X	
rhytiderus				X	X			
elongatulus	X	X						
sallei					X			
brunneus								X
melanarthrus					X			
grandis		X			X			
lateralis		X			X			
aeger		X			X			
chalchihuitlicue		X						
arboreus		X						
chirriador		X			X			
adustipennis		X	X	X	X	X	X	X
kansanus			X					
costipennis	X	X			X			
alternans		X	X	X		X	X	
viridipennis				X			X	

NAME OF SPECIES	CENTER NUMBER 1	2	3	4	5	6	7	8
rugipennis		X	X	X		X	X	
hirsutus		X						
pallidus	X							
cinctipennis		X						
cibolensis		X						
quadripennis	X		X	X		X	X	
mexicanus	X	X	X	X	X	X		
kavanaughi		X	X	X		X		
javalinopsis		X		X				
neglectus							X	
phaeocerus		X	X	X		X		
imporcitis		X						
azureipennis		X						
consanguineus		X						
oaxacensis		X						
patruelis						X		
conformis							X	
ovipennis			X	X		X		
tenuicollis		X	X	X		X	X	
cyanipennis			X	X		X	X	
medius	X	X	X	X		X	X	
gebhardis	X	X						
galactoderus		X			X			
fumans	X	X	X	X	X	X	X	

NAME OF SPECIES	CENTER NUMBER 1	2	3	4	5	6	7	8
puberulus				X				
favicollis		X						
perplexus			X	X			X	
velutinus	X							
imperialensis		X	X	X				
cordicollis		X	X			X		
cyanochroaticus	X		X			X		
sublaevis		X	X	X		X	X	
ichabodopsis							X	
oxygonus			X	X			X	
fulminatus						X		
vulcanoides						X	X	
janthinipennis			X	X		X		
mobilis							X	
explosus		X						
aabaaba		X	X	X				
sonorous		X						
TOTALS	10	34	25	25	12	21	20	2

TABLE 14.

DISSIMILARITY VALUE AMONG CENTERS OF CONCENTRATION

OF THE GENUS *Brachinus*

CENTER NUMBER	STATISTICS	CENTER NUMBER 2	3	4	5	6	7	8
1	t^1	44	35	34	22	31	29	12
	c^2	6	5	4	3	5	3	0
	$t - c$	38	30	30	19	26	26	12
	$\frac{t - c}{t} \times 100$	86	86	88	86	84	90	100
2	t^1		59	58	46	55	53	36
	c^2		13	13	9	11	7	1
	$t - c$		46	45	37	44	46	35
	$\frac{t - c}{t} \times 100$		78	78	80	80	87	97
3	t^1			49	37	46	44	27
	c^2			20	3	18	12	1
	$t - c$			29	34	28	32	26
	$\frac{t - c}{t} \times 100$			59	92	61	73	96
4	t^1				36	45	43	26
	c^2				4	15	13	1
	$t - c$				32	30	30	25
	$\frac{t - c}{t} \times 100$				89	67	70	96

CENTER NUMBER	STATISTICS	2	3	4	5	6	7	8
5	t^1					33	31	14
	c^2					3	2	1
	$t - c$					30	29	13
	$\frac{t - c}{t} \times 100$					91	94	93
6	t^1						40	23
	c^2						11	1
	$t - c$						29	22
	$\frac{t - c}{t} \times 100$						73	96
7	t^1							21
	c^2							1
	$t - c$							20
	$\frac{t - c}{t} \times 100$							95

1 = Total number of species in each pair of centers.

2 = Number of species in common between each pair of centers.

In order to locate centers of concentration, a second grid map was made by plotting only species with ranges of less than 1,000 miles. The ranges were examined for concordance, and centers of concentration were discovered. Each interval containing one or more species was lettered. Subsequently, these lettered squares were combined to provide the centers of concentration (fig. 459), and described in Table 12. The distribution of all species was compared with these centers as indicated in Table 13.

These centers were then compared with each other by a means of an Index of Difference (Ball and Freitag, in Freitag, 1969; Greenslade, 1968). Of 28 comparisons, only one scored 100, that is, a pair of centers shared no species in common. Five scored between 95 and 99, or between 90 and 94, respectively. By adding the sums in Table 14 (the Indices of Difference) for each center, an over all "Index of Dissimilarity" was obtained (Table 15). Centers 1, 5, 8 are the most distinct, probably because of their peripheral positions. Centers 3 and 4 have the lowest Indices of Difference (59) and Indices of Dissimilarity. This is probably due to their central position.

Center 8 is actually an artifact of these comparative methods because it includes two species, one of which also occurs in northern South America. The other species is represented by one very old specimen labeled "Cuba." This species is common throughout Florida and the southern United States and may have been collected in Cuba, aboard ship, or may be mislabelled. This "Center" will probably become important when the distribution of the South American fauna is studied.

TABLE 15.

INDEX OF DISSIMILARITY AMONG CENTERS OF CONCENTRATION OF THE GENUS *Brachinus* IN NORTH AND MIDDLE AMERICA DETERMINED FROM TABLE 14.

1.[1]	Center 8	673
2.	Center 5	625
3.	Center 1	620
4.	Center 2	586
5.	Center 7	582
6.	Center 6	552
7.	Center 4	546
8.	Center 3	545

1 = Arranged in order from most dissimilar to least dissimilar center.

Centers 3 and 6 share many species (Index 61), but between these centers the species of Center 6 display a pattern of subtraction westward through Center 3, and those of Center 3 display a pattern of subtraction eastward through Center 6. This pattern probably is the result of the separation of these centers by Pleistocene glaciation (Ross, 1965). Center 3 corresponds roughly to "Kansan" and "Illinoian" mammal provinces of Hagmeier and Stults (1964), while Center 6 corresponds to their "Canadian" mammal province.

Centers 4 and 7 also share many species (Index 70), but not as many as would be expected in view of the fact these Centers occur within the same climatic zone. Between these Centers is the Mississippi River, but it is highly doubtful that this relatively narrow body of water is a barrier to these highly vagile beetles. However, the long-standing Mississippi Embayment probably was a barrier, and only recently has an exchange of species apparently occurred between the centers. As in Centers 3 and 6, a pattern of mutual subtraction exists for the species of Centers 4 and 7. Center 7 corresponds to the "Austroriparian" mammal province of Hagmeier and Stults (1964) while Center 4 corresponds to their "Texan" province.

A striking correlation exists between the centers and broad climatic zones within North and Middle America. Center 1 (roughly the "Californian" and "Oregonian" of Hagmeier and Stultz) has a dry summer subtropical or Mediterranean climate, broadly referred to as a humid mesothermal climate. The northern portions of Center 1 are Marine West Coast climates with cool summers. Center 2 (a complex of many mammal provinces) has dry climates referred to as

steppes and deserts. The southern portions are subtropical steppes and deserts. Center 3 has a humid continental climate with warm summers and with rainfall throughout the year. This is broadly referred to as a humid microthermal climate. Center 4 has a humid subtropical climate with warm summers and with rainfall throughout the year. This is part of the humid mesothermal climate. Center 5 (the "Gulf Arc Component" of Martin, 1958) has a tropical rainy climate and is composed of both tropical rain forest and tropical savannahs. Center 6 has a humid continental climate with cool summers and with rainfall throughout the year. This is part of the humid microthermal climate. Center 7 has the same type of climate as Center 4. Center 8 has the same type as Center 5. The limits of these centers correspond very well with the limits of the broad climatic zones as defined by Espenshade (1964).

In summary, bombardier beetle movements are hardly influenced by physical barriers. Their high vagility allows them to pass over or around most barriers present now, and in the past, in North and Middle America. One notable exception may have been the Mississippi Embayment, in the past. The eight centers of concentration illustrated in figure 459 have apparent boundaries that are climatic in nature. It is interesting to note that in the same area (North and Middle America) mammals have at least 48 provinces defined by various authors, while bombardier beetles have eight. Also, _Evarthrus_ has eight, but just in eastern North America. _Evarthrus_ "Centers" 1, 5, 7, and 8, and part of 3 and 4 correspond to _Brachinus_ Centers 7, 4, 3, and part of 6, respectively.

7.33 Historical Zoogeography

The lack of fossil evidence of members of Brachinus in North and Middle America dictates that the history of this group must be interpreted by indirect means. Using the data given above, and that in Section 6, a hypothetical reconstruction of the history of the group can be made. The time of entrance into the New World was discussed above. The subsequent history of the New World species may be deduced from their present distribution, seeming dependence upon broad climatic zones, and vicariant sister groups.

The ancestral lineage probably entered North America in the early Tertiary when conditions of climate and relief were much different than they are now. Subtropical conditions extended to 60° N and the great inland Cretaceous Sea extended almost to the present Canadian Border (Axelrod, 1958). North of that sea, as well as further east, Arcto-Tertiary Geofloral elements predominated, while in the west the Neotropical-Tertiary Geoflora predominated. The Cretaceous Sea was rapidly retreating from its epicontinental position. In the area now called the American Southwest, the Madro-Tertiary Geoflora was arising.

Rapid spreading of the ancestral Brachinus lineage must have taken place in a southerly direction in order for at least one species to have invaded the South American Continent before it became separated from Middle America in the Eocene by a water gap. As a result of this water gap there was only a very little amount of faunal exchange (if any) between Middle and South America for a long period of time. This has resulted in the distinctive South American fauna of today,

and in the pattern of subtraction displayed by some of these South American forms (texanus group, lateralis group, sallei group, brunneus group and grandis group), as they have recently spread northward into Mexico and rarely into the southern United States.

During the Eocene and early Oligocene, supplemental angiosperm flora was added to the flora already existing in the southeastern United States (Graham, 1964). The nature of this flora was tropical, and with it probably came elements of the tropical fauna existing in the southwestern United States, including the ancestral stock of the alternans group. It is probably from these areas in the southwestern and southeastern United States that subsequent radiation spread species into the Arcto-Tertiary habitats of the north and east (cordicollis group, fumans group in part), into the newly forming Madro-Teritary habitats of the west (costipennis group, hirsutus group, fumans group in part, explosus group, and aabaaba group), and the subsequently formed grasslands and savannahs (kansanus group, fumans group in part). From those centers, the geographical history of the North and Middle American bombardier beetles is untraceable because of the lack of fossil clues, the predominantly sympatric distribution of a majority of extant species, and the lack of habitat data which might be used to trace histories of stenoecious species. However, the distribution of extant sister species may provide evidence of locations of former or present barriers, if the sister species are parapatric or allopatric. Only 12 pairs of Neobrachinus species have these types of distribution, but they provide information which might suggest how diversity has been generated in the North and Middle American Brachinus.

TABLE 16.

DISTRIBUTION PATTERNS OF ALLOPATRIC SISTER SPECIES OF THE GENUS Brachinus IN NORTH AND MIDDLE AMERICA

EAST - WEST RELATIONSHIPS

WESTERN VICAR		EASTERN VICAR	
NAME	CENTER	NAME	CENTER
mexicanus	1, 2, 3, 4, 5, 6	kavanaughi	2, 3, 4, 6
javalinopsis	2, 4	neglectus	7
imporcitis	2	phaeocerus	2, 3, 4, 6
sonorous	2	aabaaba	2, 3, 4
melanarthrus	5	brunneus	8

NORTH - SOUTH RELATIONSHIPS

NORTHERN VICAR		SOUTHERN VICAR	
NAME	CENTER	NAME	CENTER
gebhardis	1, 2	galactoderus	2, 5
cibolensis	2	cinctipennis	2
pallidus	1	hirsutus	2
cordicollis	2, 3, 6	sublaevis	2, 3, 4, 6, 7
fulminatus	6	oxygonus	3, 4, 7
texanus	3, 4, 6	rhytiderus	4, 5
velutinus	1	imperialensis	2, 3, 4

Among the extant sister species of North and Middle American Brachinus, two types of vicariant relationships exist. These are east-west and north-south relationships and are listed in Table 16. These taxa are discussed below in phylogenetic sequence. The widespread distributions of the other species of Brachinus in North and Middle America does not even allow speculation concerning their geographic origins. The acquisition of additional habitat data may alter this situation in the future. For example, if species are restricted to marshes or to river drainage systems, then the histories of these habitats may provide clues to the history of the beetles.

The species B. texanus and B. rhytiderus of the texanus species group are derivatives of a South American complex which began spreading northward, probably in the Pliocene. B. rhytiderus (fig. 110) is essentially a species of the humid tropics, but in the north it has spread into thorn scrub. B. texanus (fig. 108) is essentially a species of woodlands, grasslands, and temperate humid forests, but in the south it enters thorn scrub. This area of thorn scrub was probably vast grassland during late Pliocene times (Cohn, 1965). It is possible that the ancestral stock was separated by grassland conditions into a northern and southern component and subsequent development of thorn scrub on both sides of the Rio Grande River may have allowed these groups to become parapatric in southern Texas. The limited movement into thorn scrub areas by both groups was probably secondary. Further study may show that the present occurrence in the thorn scrub is along river courses with more luxuriant vegetation rather than the surrounding thorn scrub.

Speciation of the _brunneus_ group probably occurred in South America but there is no evidence of exactly where this took place. One sister species, _B. brunneus_ (fig. 134) has spread northward along the Lesser Antilles to at least Haiti in the Greater Antilles, while the other sister species, _B. melanarthrus_ (fig. 132) spread northward into Mexico and presently occupies the "Gulf Arc."

The species of the _hirsutus_ group (_B. pallidus_ and _B. hirsutus_) have been only recently separated and have diverged little in their morphological characteristics. The members of _B. pallidus_ (fig. 218) are distributed in the Mediterranean climatic zone of California, north of the Tehachapi Mountain range, while the members of _B. hirsutus_ (fig. 220) are distributed on the High Plateau of Mexico and in the American Southwest. The development of intense desert conditions in the Pleistocene in the area of southeastern California and western Arizona probably separated this lineage, and speciation occurred. The northern group became adapted to humid coastal conditions and the southern group became adapted to subdesert conditions in the Mojave and Chihuahua Deserts.

The species of the _cinctipennis_ subgroup are presently distributed on the Mexican High Plateau, in southern Arizona, and in New Mexico. The two sister species are closely related, and any factor that separated them must have developed rather recently. Martin (1958) suggested that a continuous woodland corridor connected the Sierra Madre Oriental and Occidental. Cohn (1965) supported Martin's findings. This corridor probably existed across northern Durango and southern Coahuila in the Pliocene and early Pleistocene. Such a condition may have separated populations of the ancestral

cinctipennis-cibolensis stock long enough for speciation to occur. B. cinctipennis (fig. 221) may have become a centrant (see below) species during that time, for it has not spread northward. But B. cibolensis (fig. 219) did spread southward, extending as far as Durango City. (The actual ranges of the two species do not overlap, however.)

Two species of the quadripennis subgroup exhibit sister relationships and are parapatric, however, the extent of overlap is such that definite statements cannot be made. It appears that the Rocky Mountains and southern deserts may be partial barriers to the eastern or western movements of B. mexicanus (fig. 252), and full barriers to the westward movements of B. kavanaughi (fig. 253).

Two other species of the quadripennis subgroup exhibit east-west vicariance and are presently separated by the Mississippi Embayment region. Inundation of the Mississippi River Valley in the Pleistocene (Ross, 1965) may have separated a once widespread southern species long enough so that speciation occurred. This also may explain why Centers 4 and 7 are relatively distinct (Index 70), but still occur within the same broad climatic zone. The species confined to Florida became "centrants" (Ball and Freitag, in Freitag, 1969) by loss of variability, due in turn to reduction in population size in a small confined area. On the other hand, the species west of the Embayment had a large area over which to spread, and became "radiants." The species B. neglectus (fig. 255) of the southeast, and B. javalinopsis (fig. 254) of the southwest display this type of distribution.

Two sister species of the phaeocerus subgroup exhibit east-west

vicariance. They are presently separated by the Chiricahua Mountains, Peloncillo Mountains, and San Francisco Mountains of eastern Arizona and western New Mexico: B. imporcitis (fig. 278) occurs in the west and B. phaeocerus (fig. 279) in the east, and the two species meet and apparently hybridize in the narrow Gila River system between the Peloncillo and Chiricahua Mountain ranges. Separation of these two species must have occurred long ago, because the western group (imporcitis) has reduced wings, and is also quite different in several morphological and color characteristics. Further north in Colorado, B. phaeocerus does not cross the Rocky Mountains. The orogeny of the Arizona mountain systems mentioned above in the Late Pliocene-Pleistocene (Cohn, 1965) may have separated the ancestral stock, and more recently B. phaeocerus has extended its range into the Gila system. The more northern Rockies have probably always been a barrier to B. phaeocerus.

The species of the gebhardis subgroup (figs. 332, 333) display the pattern described for the hirsutus group, presumably for the same reasons given in that discussion. The same is true for B. velutinus (fig. 367) and B. imperialensis (fig. 364) of the fumans subgroup.

Two species pairs of the cordicollis group (figs. 390, 392, 414, 416) display north-south vicariance in the eastern half of the United States. It is difficult to discuss any prehistoric physical barriers that might have brought about separation in these cases, but there are presently possible climatic barriers. It also is possible that speciation was brought about during glacial stages when species now widespread were restricted to more southern "pockets."

The present distributions of the species of Brachinus in North and Middle America are influenced by broad climatic zones. Development of the present distribution patterns has been mainly under the influence of climatic changes, and to a lesser extent physical barriers.

The climatic changes that have had much influence are those which developed in the American Southwest and on the Mexican High Plateau. Physical factors that have had much influence are the orogeny of the various western mountain ranges, the inundation of the Mississippi River Valley, and the separation of the Great Plains from eastern North America by glacier lobes.

The major center (fig. 459) of North and Middle American Neobrachinus dispersal has been the American Southwest and northern parts of the Mexican High Plateau. Minor centers (fig. 459) include the southeastern United States, probably in peninsular Florida, and in the northeastern United States. From these centers dispersal has occurred as follows. Centers 1, 3, 4, and 6, and possibly 7, have received species from Center 2. Center 1 has received species mainly from Center 2, but also from Centers 3 and 6. Center 6 has received species from Centers 2, 3, and 7. Centers 5 and 8 have received species from South America.

Thus each center has received species from other centers (addition); each center has lost species to other centers (subtraction); and species of each center have differentiated within that center (multiplication). Within these centers, differentiation has taken place resulting from climatic shifts which, in turn, shift the centers of concentration, and hence,

at least part of the fauna. These shifts result in isolation of older "pocket" groups (Centrants) in the former range and new terrain in the acquired range. During these climatic fluctuations, isolation results in speciation. To a lesser extent in bombardier beetles, geological changes have resulted in isolation which in turn has led to speciation.

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